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Space Shuttle Program

FINAL SUBMITTAL

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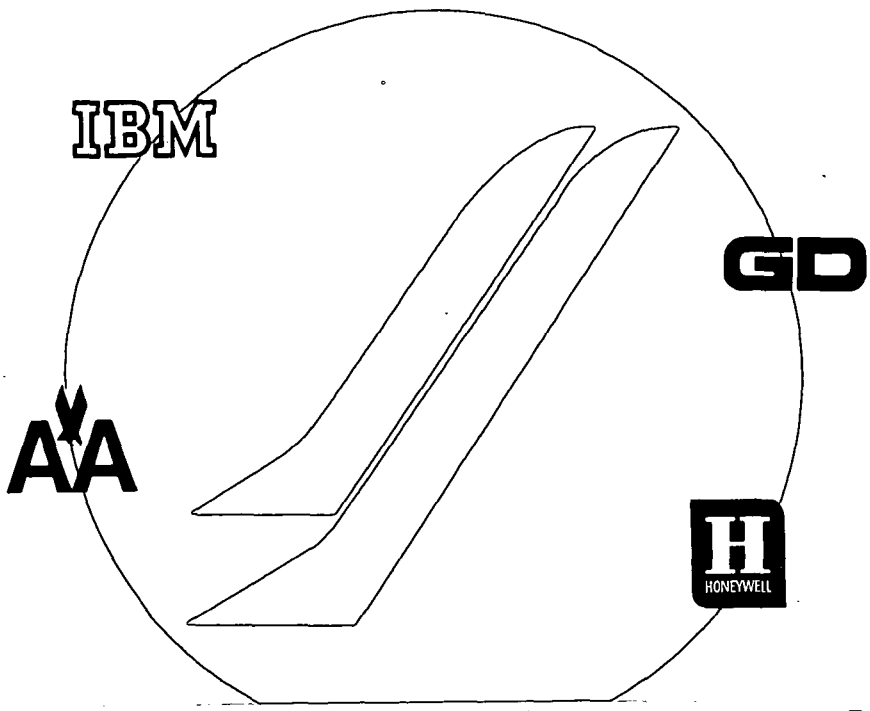

(NASA-CR-146118) SPACE SHUTTLE PHASE C/D BASELINE. VOLUME 3: WORK BREAKDOWN STRUCTURE DICTIONARY (North American Rockwell Corp.) 218 p

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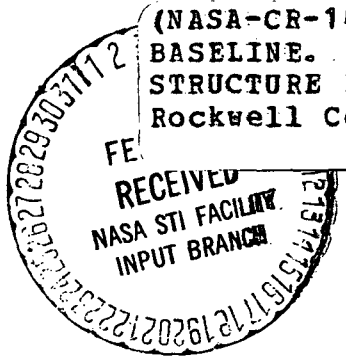
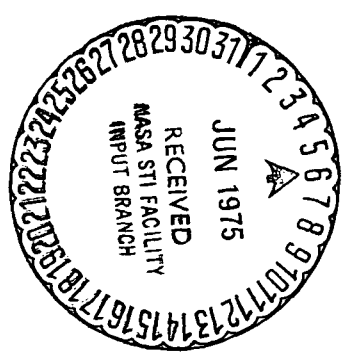


Phase C/D Baseline

Volume III. Work Breakdown Structure Dictionary



Contract NAS9-10960
DRL M010, DRL Line Item 19
DRD MF003M
SD 71-124-3
25 June 1971

Space Division • North American Rockwell 12214 Lakewood Boulevard, Downey, California 90241

SD 71-124-3
(MSC-03314)

25 June 1971

SPACE SHUTTLE

PHASE C/D BASELINE

Volume III
Work Breakdown Structure Dictionary

Approved by

B. Hello
Vice President and General Manager
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Contract NAS9-10960
DRL M010, DRL Item 19
DRD MF003M

Space Division • North American Rockwell 12214 LAKEWOOD BOULEVARD • DOWNEY, CALIFORNIA 90241

SPACE SHUTTLE PROGRAM WORK BREAKDOWN STRUCTURE

INTRODUCTION

The Space Shuttle Program Work Breakdown Structure (WBS) has been designed to display, in a product oriented family tree, functionally similar units of work that form a framework for management and control of technical software and hardware development, schedule plans and status, and cost accumulation. The units of work are subdivided into manageable elements for which there are technical definitions, schedules and resource application estimates that can be statused in reportable packages. This issue of the WBS is in consonance with the Shuttle Master Program Schedule, refer. MPS-05, REV. 1.

Detailed technical definitions for all WBS elements were developed to provide adequate identification of hardware, software, and significant services that are necessary to the accomplishment of the Shuttle Program Objectives.

The major level 3 segments of the Shuttle Program, selected by the NASA are:

Element	Level
0.0 Shuttle Program	2
1.0 Orbiter	3
2.0 Main Engine	3
3.0 Booster	3
4.0 Flight Test	3
5.0 Operations	3
6.0 Shuttle Management and Integration	3

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Below level 3, the contractor has developed in concert with the NASA, the basic level 4 elements. In general, the contractor and the NASA are in agreement on level 4, however, the contractor has retained a degree of flexibility that enables him to exercise ingenuity and creativity in the final selection of the level 4 elements, and in the choice of level 5 and lower level elements, that are meaningful and useful as management oriented subdivisions.

It should be noted, that the complexity of individual elements may require subdivision to lower levels. The reporting level often may vary from level 4 to as low a level as the contractor considers necessary for adequate management.

After selection of the WBS elements, the functional tasks and responsibilities of each element will be defined and recorded in functional work units. The functional work units and tasks will be scheduled, budgeted, controlled, and reported in "work packages" by the Functional Group responsible for the tasks.

With the completion of the product oriented and functional oriented work units definition, there exists a product/functional interface for management of the Shuttle Program WBS elements.

PHASE B - CONTRACT NAS9-10960, DRL ITEM 19,
DRD MF00 3M, PARA. 7

SPACE SHUTTLE PHASE C/D WSB DICTIONARY

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LEVEL	3	4	5
	X.0	X.X	X.X.X
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		6.2	SYSTEM ENGINEERING AND INTEGRATION
		6.3	PAYLOAD INTEGRATION

WBS BLOCK DIAGRAM

1.0 ORBITER

The Orbiter element sums all lower level elements identifiable and peculiar to the Orbiter system including all vehicle subsystems; mockups and models; integration, assembly checkout of the vehicle; subsystem tests; facilities for administration, manufacturing and test; system support including handling, checkout and servicing equipment, Orbiter peculiar Support Equipment, standard test equipment, ground tests propellants and gasses, training and training equipment, provisioning, and technical data; and the program management elements of contract management, configuration management, program documentation, and program planning and control.

The effort includes all Orbiter peculiar design, development, production and support.

1.1 STRUCTURAL SUBSYSTEMS GROUP

This element sums all of the effort and materials required to design, develop and produce the primary and secondary structural elements which comprise the basic Orbiter Vehicle structure. The lower level elements include body structure, fixed and moveable aerodynamic surfaces, thermal protection, landing, docking, and payload deployment and retrieval subsystems. Included in this element are all prototype, development, production, test and support articles and design and fabrication of mockups.

1.1.1 BODY STRUCTURE SUBSYSTEM

The body structure subsystem element refers to fixed structure of the Orbiter Vehicle. This element includes forward, mid and aft body assemblies (which include frames, stringers, panels, equipment and crew compartments, cargo bay and doors, bulkheads and thrust structures), main propulsion cryogenic tankage, fittings, adaptors, ground handling and jacking provisions. It also includes all design, development and production of complete units, or intact sub-assemblies installable in the Orbiter Vehicle. Fabrication of subsystem mockups are included as part of design.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.1.1 BODY STRUCTURE SUBSYSTEM (Continued)

This element also includes the manufacture of one additional main propulsion LH_2 tank and one additional LO_2 tank for structural fatigue testing.

1.1.2 AERODYNAMIC SURFACES

The aerodynamic surfaces subsystem element refers to all primary lifting and aerodynamic control surfaces, both fixed and movable, of the Orbiter Vehicle. This element includes wings, vertical stabilizer and control surfaces such as elevons, rudder, speed brake, etc. (structural elements include ribs, spars, hinges, doors). It also includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Fabrication of subsystem mockups and breadboards are included as part of design and development.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification

1.1.2 AERODYNAMIC SURFACES (Continued)

and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

This element also includes the additional vertical stabilizer required for structural fatigue testing.

1.1.3 THERMAL PROTECTION SUBSYSTEM (TPS)

The TPS subsystem element refers to the fixed external structure which serves to control the Orbiter Vehicle (body structure) temperatures during ascent and entry. This element includes heat shield panels and/or subsurface low-density insulation; it may also include provision (passive) for limiting temperature of non-structural components. It also includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Fabrication of subsystem mockups are included as part of design.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.1.4 LANDING SUBSYSTEM

The landing subsystem element refers to deployable subsystem required to support and cushion the Orbiter Vehicle while landing. This element includes, main landing gear, nose landing gear, landing extension/retraction subsystem, landing-gear-door hinges and actuators, latches, brakes and wheels, auxiliary deceleration devices (as required), sensors, etc. It also includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle; design and fabrication of mockups and breadboards are included.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.1.5 DOCKING SUBSYSTEM

The docking subsystem element refers to the Orbiter Vehicle subsystem required to enable the Vehicle to dock with a payload module, a space station/base, or another Orbiter. This element includes, docking adaptor, pressure seals, visual/optical aids, monitoring devices, latches, sensors, etc. It also includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle and design and fabrication of mockups and breadboards are included.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.1.6 PAYLOAD DEPLOYMENT AND RETRIEVAL SUBSYSTEM

The payload deployment and retrieval subsystem element refers to the Orbiter Vehicle equipment/mechanisms required to handle/move/retrieve payload modules, or portions thereof, while in earth orbit. This element includes, payload deployment/retrieval manipulators, controls, sensors, etc. It also includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle; the design and fabrication of mockups and breadboards are included as part of design and development.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.2 PROPULSION SUBSYSTEM GROUP

This element sums all of the effort and materials required to design, develop, produce and/or integrate the primary and secondary propulsion subsystems into the Orbiter Vehicle. As such it includes the integration and installation of the main rocket, airbreathing, attitude control and orbital maneuvering engines. It specifically excludes main rocket engine design, development and production. Design, fabrication and test of assigned Booster/Orbiter common equipment is included in this element.

1.2.1 MAIN PROPULSION SUBSYSTEM

The main propulsion subsystem element refers to the Orbiter Vehicle propulsion and applicable booster common equipment required to boost the vehicle into injection orbit after separation from the Booster Vehicle. This element includes, tankage pressurization provisions, tankage venting provisions, tank gaging and PU provisions, propellant distribution provisions; it does not include cryogenic tankage (which is considered to be vehicle structure) and the engines (which are GFE); it does include integration of the engines into the subsystem. It also includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Design and fabrication of mockups and breadboards are included. Test operations supporting static firing test articles are excluded.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production, flight test and operations of the basic equipment included in this element.

1.2.1 MAIN PROPULSION SUBSYSTEM (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation at the subassembly level of sensors/transducers which are an integral part of this subsystem are also included.

1.2.2 AUXILIARY PROPULSION SUBSYSTEM

The auxiliary propulsion subsystem refers to the orbiter vehicle propulsion and applicable common booster equipment which provides the capability for orbital maneuvers; circularization, orbit transfer, rendezvous and deorbit; for three axes attitude control, except when mated to the booster and during atmospheric flight when the vehicle is controlled by the aerodynamic surfaces; and for small three-axes translational maneuvers during orbital operations. This element consists of: cryogenic tankage, engines, thrusters, tankage pressurization provisions, tankage venting provisions, propellant gaging provisions, propellant conditioning provisions, propellant distribution provisions, and necessary controls and instrumentation.

This element includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter vehicle and design and development of applicable common booster equipment. Design and fabrication of mockups, breadboards, and test articles is included. Production of Booster common equipment is excluded.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during manufacture and flight test is included. Inspection, and subsystem development test and equipment are included. Test operations of static firing test programs are excluded.

1.2.2 AUXILIARY PROPULSION SUBSYSTEM (Continued)

This element also includes the design, development, manufacture of spares and repair parts in support of production flight test and operations of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation at the subassembly level of sensors/transducers which are an integral part of this subsystem are also included.

1.2.3 AIR-BREATHING PROPULSION SUBSYSTEM

The air-breathing propulsion subsystem element refers to the Orbiter Vehicle propulsion which provides capability for (1) short-duration powered descent after entry, (2) powered landing approach and go-around, and (3) ferry flight between airports. This element includes: air-breathing gas turbine engines, engine installation system i.e., built up engine and installation requirements, air induction system, fuel system including tankage, controls and instrumentation system, engine starting system and hazard protection system. It also includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Design and fabrication of mockups, breadboards and test articles.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. Test operations for static firing articles are excluded. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production, flight test and operations of the basic equipment included in this element.

1.2.3 AIR-BREATHING PROPULSION SUBSYSTEM (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation at subassembly level of sensors/transducers which are an integral part of this subsystem are also included.

1.3 AVIONICS SUBSYSTEM GROUP

This element sums all of the effort and materials required to design, develop and produce all items comprising the avionics subsystem and the integration of these into the Orbiter Vehicle. The lower level elements include GN&C, Data & Control Management (including COFI), Software, Displays and Controls, Communications and Instrumentation. Included in this element are all prototype, development, production, test and support articles including the design and fabrication of mockups and assigned common equipment.

Special consideration will be given in all WBS elements to safety criteria and reliability objectives.

1.3.1 GUIDANCE, NAVIGATION AND CONTROL (GN&C) SUBSYSTEM

The GN&C subsystem element refers to the Orbiter Vehicle subsystem which performs navigation, guidance and control functions in a nominal, pilot-initiated, automatic flight mode. This element includes, drive/pickoff electronics, star tracker, rate sensors, aero surface servo amplifiers, air data sensors and processors, ACPS valve drivers, thrust vector servo amplifiers, IMU, dedicated GN&C displays and controls, computer algorithims peculiar to the GN&C functions. It includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle (prototype or operationally configured units which satisfy the requirements of their applicable specifications, regardless of their end use); design, fabrication and operation of mockups, simulators and breadboards are included. Major test activities will include laboratory simulators, flying test bed programs, and system integration lab tasks.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.3.1 GUIDANCE, NAVIGATION AND CONTROL (GN&C) SUBSYSTEM (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

Special consideration will be given to safety criteria and reliability objectives.

1.3.2 DATA AND CONTROL MANAGEMENT (DCM) SUBSYSTEM

DCM subsystem provides Orbiter Vehicle automated control and system/subsystem management for multimode multi-mission capability. This element includes: main memory complexes, mass memory units, ACT (Acquisition, Control and Test) units, data management computer, data bus control, mass memory control unit, main data bus, and line coupling units. This subsystem also includes all effort related to definition and development of the onboard checkout and fault isolation capability (COFI). It includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Design, fabrication and operation of mockups, simulators and breadboards are included. Major test activities will include laboratory simulators, and system integration laboratory tests.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.3.2 DATA AND CONTROL MANAGEMENT (DCM) SUBSYSTEM (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

Special consideration will be given to safety criteria and reliability objectives.

1.3.3 DISPLAYS AND CONTROLS

The displays and controls subsystem element refers to displays and controls, located at the Orbiter Vehicle flight crew station and closely tied in to the DCM computer complex. This element includes, multiformat CRT display, alphanumeric display and buffer, caution and warning, manual flight controls and buffer, multifunction flight controls and buffer, sensors, panel design, and crew/passenger lighting design. It includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Design, fabrication, and operation of mockups, simulators and breadboards are included. Major test activities will include laboratory simulators, and system integration laboratory tests.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.3.3 DISPLAYS AND CONTROLS (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

Special consideration will be given to safety criteria and reliability objectives.

1.3.4 COMMUNICATIONS

The communications subsystem element refers to the Orbiter Vehicle subsystem which provides two-way voice and data transmission, ranging retransmission, acquisition and ranging with cooperative targets, booster/orbiter data link, and electromagnetic aids for navigation and landing. This element includes, antennas, antenna selectors, precision ranging system interrogator, up-data link equipment, VHF/FM transceivers, UHF/AM transceivers, S-band power amplifier, Unified S-band Equipment, signal processors, flight log recorder, VHF Recovery beacon, audio center equipment, ATC transponders, and radar altimeters. It includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Design, fabrication and operation of mockups, simulators, and breadboards are included. Major test activities will include laboratory simulators, and system integration laboratory tests.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.3.4 COMMUNICATIONS (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

Special consideration will be given to safety criteria and reliability objectives.

1.3.5 INSTRUMENTATION SUBSYSTEM

This element comprises the activities required to provide an Orbiter Vehicle operational instrumentation subsystem including establishment of general instrumentation requirements criteria for all interfacing vehicle subsystems, payload container, and ground subsystems. Included is the definition, specification preparation, installation design, acquisition, and test for all common requirements including on-board recorders, central timing equipment, telemetry format generators, signal conditioning/buffering equipment and end item sensors which are not unique to a using subsystem.

The activities required to provide a Development Flight Instrumentation (DFI) system are also included. The DFI includes a DFI format controller, recorders, DFI controls and displays, DFI acquisition and signal conditioning units, and Frequency Modulation units. Included is the definition, specification preparation, installation design, acquisition, and test for all common DFI requirements.

Design, fabrication, and operation of mockups, breadboards, and simulators is included. All costs for the design, manufacture and procurement of tooling required to produce the common operational instrumentation and the DFI are included. The maintenance of tooling during production and flight test is included, but tooling maintenance during the flight operational period is excluded. Subsystem development test and equipment are included. This element also includes inspection.

1.3.5 INSTRUMENTATION SUBSYSTEM (Continued)

This element also includes the design, development, and manufacture of spares and repair parts in support of production, flight test, and operations.

1.3.6 SOFTWARE

This element includes the design, development, qualification, processing and implementation of all Orbiter software (computer languages, computer programs, program verification, debugging, etc.), for all elements of the avionics subsystem group. GN&C (except unique algorithms), communications, data and control management, on-board checkout (failure predicition), integrated displays and controls (caution and warning), power distribution and controls, and instrumentation. Shuttle Program ground systems software design, development, qualification, production and change control are also included. The program performance specification, the program design specification, the detail subprogram design specification, the data base design specification, the program operating manual specification, the program test plans and test procedures specification, and the test program specification software requirements will be provided.

This element also includes the design, development, production, and operational costs in support of breadboards, simulators, and flight test programs. Major test programs will include laboratory software and hardware simulators, and avionics system integration laboratory tests. Also included are the maintenance and mission-peculiar modifications required in support of the basic shuttle test programs and flight operations.

Special consideration will be given to safety criteria and reliability objectives.

1.4 POWER SUBSYSTEMS GROUP

This element sums all of the effort and materials required to design, develop and produce those Orbiter Vehicle subsystems and assigned common Booster equipment as applicable on a commonality basis which provide electrical and mechanical power. The lower level elements include electrical/mechanical power sources and generation and hydraulic power. Included in this element are all prototype, development, production, spares, and test articles, and the design and fabrication of mockups and breadboards.

1.4.1 ELECTRICAL/MECHANICAL POWER GENERATION SUBSYSTEM

The electrical/mechanical power generation subsystem element refers to the Orbiter Vehicle subsystem which generates the electrical and mechanical energy for operation of the electrical/avionic subsystems and hydraulic power subsystem. This element includes, H_2/O_2 turbine auxiliary power units; H_2/O_2 fuel cells; AC generators, rechargeable batteries; fluid boilers; heat exchangers; reactant storage tankage; reactant distribution network; and controls, sensors, connecting plumbing, etc. It also includes all design, development, and production of complete units or subassemblies installable in the Orbiter Vehicle and assigned common equipment. Design and fabrication of mockups, breadboards and test articles are included.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. Test operations of integrated system tests are excluded. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production, flight test and operations of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and

1.4.1 ELECTRICAL/MECHANICAL POWER GENERATION SUBSYSTEM (Continued)

installation at subassembly level of sensors/transducers which are an integral part of this subsystem are also included.

1.4.2 HYDRAULIC POWER SUBSYSTEM

The hydraulic power subsystem element refers to the Orbiter Vehicle subsystem which provides the large amounts of power to move/deploy such equipment as the thrust vector control system, aerodynamic control surfaces, Air Breathing Engines, landing gear, brakes, steering, etc. This element includes, hydraulic pumps, hydraulic lines, valves, actuators, sensors, and all assigned common equipment. Design, development and production of complete units and intact subassembly is included.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. Test operations for integrated systems tests are excluded. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production, flight test and operations of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation at subassembly level of sensors/transducers which are an integral part of this subsystem are also included.

1.4.3 ELECTRICAL POWER DISTRIBUTION AND CONTROL SUBSYSTEM

The electrical power distribution and control subsystem element refers to the subsystem which distributes and controls electrical power to all Orbiter Vehicle subsystems. This element includes, power buses, inverters, transformer-rectifiers, battery charger, power control, and protection units, electrical connectors, electrical cables, generator control units, lighting, interlocks, and sensors. It does not include computer functions concerned with electrical power control and energy management. It includes all design, development and production of complete units, or intact subassemblies installable in the Orbiter Vehicle. Design, operation and fabrication of mockups, simulators and breadboards are included. Major test activities will include laboratory simulators, flying test bed programs, and system integration laboratory tests.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.4.3 ELECTRICAL POWER DISTRIBUTION AND CONTROL SUBSYSTEM (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

Special consideration will be given to safety criteria and reliability objectives.

1.5 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SUBSYSTEMS

This element sums all of the effort and materials required to design, develop and produce all items comprising the subject system and the integration and installation of these items in the Orbiter Vehicle. It also covers furnishing assigned common items to the Booster contractor for his integration and installation in the Booster Vehicle. The lower level elements include the environmental Control and Life Support System and the Flight Personnel Provisions Subsystem. Included in this element are all prototype, development, production, and test articles, including the design and fabrication of mockups.

1.5.1 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SUBSYSTEM (ECLSS)

The ECLSS element refers to the Orbiter Vehicle subsystem which provides thermal control for on-board equipment and provides a shirt-sleeve environment, water management, waste management, heat sinks, etc. This element includes gas storage vessels, heat exchangers, LiOH elements, activated charcoal, space radiators, supplementary water evaporators, portable oxygen bottles and face masks, fecal collector, utensil storage cabinet, potable water system, waste management system, ovens, freeze lockers, etc. It also includes all design, development, and production of complete units, or intact subassemblies installable in the Orbiter and assigned common items. Vehicle design and fabrication of mockups, breadboards and test articles are included.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. Test operations for integrated systems tests are excluded. This element also include inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production, flight test and operations of the basic equipment included in this element.

1.5.1 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SUBSYSTEM (ECLSS) (Continued)

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation at subassembly level of sensors/transducers which are an integral part of this subsystem are also included.

1.5.2 FLIGHT PERSONNEL PROVISIONS SUBSYSTEM

The flight personnel provisions subsystem element refers to a selected set of Orbiter Vehicle equipment/mechanisms/supplies required to enable the flight crew to perform their mission functions. This element includes: crewman couches/ejection seats; crew sleep provisions; containers, retainers and cushions; crew communication umbilical; tool kit; crew escape ropes; mirror, crew handholds; crew window shades; installation interfaces and/or stowage provisions for support of 2 crewmen and 2 passengers, including certain items of GFE. It does not include: consumables, items listed under displays and controls, ECLSS (food oven, chiller, potable water, waste management system); items listed under structures (i.e., windows and hatches) and other WBS elements.

This subsystem element also includes all design, development and production of complete units or intact subassemblies installable in the Orbiter Vehicle, as well as design and fabrication of mockups.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.6 ORBITER VEHICLE INSTALLATION, ASSEMBLY, AND CHECKOUT

This element refers to the tasks related to the installation and checkout of subsystems, or elements thereof, in a flight configured Orbiter Vehicle (flight test vehicle, operational vehicle, and vehicles recycled to the Manufacturer for modification), including five (5) flight vehicles, one (1) static structural test article, and one (1) propulsion static firing test article.

Installation includes those tasks necessary to assemble subsystems, assemblies, components, etc. into fully or partially completed structural subsystem elements or modular sections thereof and final installations into a complete vehicle.

Checkout includes those tasks related to verification of the physical and functional adequacy of the installations and installed equipment up to and including integrated systems checkout.

Included in this element is all production planning, test and checkout procedures, and process specification development and maintenance associated with the installation and checkout defined above.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.6.1 SUBSYSTEM INSTALLATIONS

This element refers to the tasks associated with installation and in-process checkout of subsystems (or portions thereof) in modular sections of the body structure and/or aerodynamic surfaces prior to mating of the modules into a complete body structure or installation of aerodynamic surfaces to the body structure. This element also includes inspection.

1.6.2 VEHICLE FINAL ASSEMBLY

This element refers to the tasks associated with installation and in-process checkout of subsystems (or portions thereof) in the Orbiter vehicle subsequent to structural mating of the body structure elements (modules), including installation or aerodynamic surfaces and thermal protection subsystems to the body structure. This element also includes inspection.

1.6.3 VEHICLE INTEGRATED CHECKOUT

This element refers to the tasks associated with checkout of the completed Orbiter vehicle involving verification of the physical and functional validity of the subsystem installations and the integration of multiple subsystems in their proper integrated sequence (prior to turnover to flight test operations).

1.6.4 PRODUCTION SUPPORT

This element sums all of the level of effort type activities and products associated with the Orbiter Vehicle, but which are not identifiable to any specific subsystem, other product, or service.

This element includes quality planning, usage type material, and manufacturing planning.

1.7 COMBINED SUBSYSTEM DEVELOPMENT TESTING

This element refers to the work effort and materials required to perform development tests involving two or more subsystems. It includes all integrated subsystems test planning, operations, evaluation, and inspection for structural static testing, and propulsion static firing. It specifically includes ground tests for the development of Orbiter peculiar support equipment with the Orbiter Vehicle subsystems. It does not include flight tests or major ground tests in support of or preparation for flight tests, or subsystem and system checkout, on flight vehicles.

1.7.1 MAIN PROPULSION TEST PROGRAM

This element encompasses the effort and support required to conduct the Orbiter main propulsion system static firing program. It includes the test activities necessary to integrate the elements of the main propulsion subsystem with the support equipment, facilities, data acquisition and processing system/facility, and base support services. It includes all test operations planning, operations, test operations data evaluation, test operations reporting, pre- and post-static firing checkout, instrumentation and equipment calibration. Included are the support and services for maintenance and modification of the main propulsion test article and associated support equipment. It does not include modification and maintenance of the main engines.

1.7.2 STRUCTURAL TEST PROGRAM

This element encompasses the effort and support required to conduct the Orbiter structural test program on the Structural Test Article. It includes the test activities necessary to set up and integrate the elements of the structural test article(s) with the test laboratory and its supporting equipment, instrumentation and data acquisition systems. It includes all test operations planning operations, data acquisition and processing, test operations and data evaluation, test operations reporting, checkout and calibration. Included are the support and services for the test article, support equipment and installed instrumentation.

1.7.3 AVIONICS/NON-AVIONICS TEST PROGRAM

This element encompasses the effort and support required to conduct integration of the Avionics Subsystems Group with the Structural, Propulsion, Power, ECLS, Mechanical and Systems Support Groups. This activity will take place in an Avionics Systems Integration Laboratory, where actual avionics and software will be interfaced with computer models of the non-avionics subsystems. It includes all test operations, data evaluation and reporting, and instrumentation and equipment calibration.

1.7.4 ABES STATIC FIRING TEST PROGRAM

The test program preparation consists of the test hardware and support equipment activation including such elements as instrumentation calibration, fuel supply systems, checkout and calibration, and compatibility verification with the facility. The actual test program will consist of performing a series of static firings on a combined turbofan engine, nacelle, and pylon with supporting tankage and fuel distribution system to determine the overall subsystem operational performance characteristics. Data will be obtained, reduced, qualified, and reported to determine the effects of test configuration changes on overall subsystem performance. Post-test checkouts and inspections will be performed to establish assembly and subsystem test conditions and effects.

1.7.5 AUXILIARY PROPULSION STATIC FIRING TEST PROGRAM

This element encompasses the effort and support required to conduct the APS static firing program consisting of orbit maneuvering propulsion and reaction control propulsion. It includes the test activities necessary to integrate the orbit maneuvering propulsion and the attitude control propulsion such as: test planning, detailed test procedures, test operations and evaluation, data acquisition, processing and analysis, test reporting and test quality assurance surveillance. Also included are the facilities, support and services for the test equipment, support equipment, and installed instrumentation. The major assemblies include: LH_2 and LOX cryogenic tanks, OMS engines, ACPS thrusters, APU's, accumulators, valves, and operational configured lines. In addition to the operational subsystem assemblies, the test article will make provisions for interfacing with required avionics, GSE for servicing, structures for component support, and instrumentation and control. The actual test program consists of performing a series of flow tests and static firings to determine the overall subsystem operational performance characteristics. Data will be obtained, reduced, qualified, and reported to determine the effects of test configuration changes on overall subsystem performance. Post-test checkouts and inspections will be performed to establish assembly and subsystem test conditions and effects.

1.7.6 ECLSS/CREW CABIN TEST PROGRAM

This element encompasses the effort and support required to conduct the orbiter environmental control and life support subsystem integration with the crew cabin and the associated test program. It includes the test activities necessary to integrate the elements of the ECLS subsystem with the test laboratory and its supporting equipment, instrumentation and data acquisition systems and the conduct of the tests. It includes test planning, detailed test procedures, test conduct and data evaluation, data acquisition, processing and analysis, test operations reporting, checkout, and test quality assurance surveillance. Included are the support and services for the test article, support equipment, and installed instrumentation. The test article will consist of a production crew cabin shell without floors or mounting provisions. The floor, insulation, windows will be installed as test hardware. A prototype ECLS subsystem including ECS, waste management system, food management system and heat sinks will be installed. The environmental heat load, avionics heat loads and metabolic loads will be simulated. Supporting avionics such as the controls and displays will be installed as required.

1.8 SYSTEMS ENGINEERING AND INTEGRATION

This element refers to the materials and effort required to establish requirements for the design, development and integration of the total Orbiter system, common booster items, and payload container integration. It includes the design and fabrication of mockups and models. It also includes the analytical effort required to support the development of designs and that effort required to verify compatibility of designs with requirements and to control and direct the engineering activities for the design of the Orbiter System.

1.8.1 SYSTEM ANALYSIS & INTEGRATION

This element refers to the engineering activities required to conduct mission analysis, to define total system requirements (Orbiter and support systems), mission planning, mission operations analysis, contingency analysis, system capability analysis and the establishment of requirements for mission simulation programs. Included is the activity required to analyze and define Orbiter system performance and design requirements, test requirements, reliability, maintainability, safety, and the preparation of specifications and interface control document requirements. It also includes integration of the payload container and common Booster items, integration of support subsystems and facilities, software integration, the preparation and integration of system level schematic diagrams, the technical planning of engineering activities to assure timely development of the Orbiter system, including test planning, maintenance planning, engineering planning for production and operations, configuration control and accounting, system cost effectiveness analysis, technical performance measurement (TPM) and integration of all flight and ground test; training and operational requirements.

1.8.2 DESIGN ANALYSIS

This element refers to those analytical engineering activities that support the development of Orbiter system design, but cannot be identified specifically with other WBS elements. Included in this element are aerodynamic and aerothermo dynamics, flight mechanics and wind tunnel testing related to these analytical tasks, and human factors requirements analysis for the Orbiter system. Also included are the efforts related to structural analysis, structural dynamics and the selection of materials and processes to be used on design and fabrication of the Orbiter system.

1.8.3 MODELS AND MOCKUPS

This element refers to the design and fabrication of models and mockups of the Orbiter vehicle or major portions thereof involving two or more subsystems. This includes scale models, cabin models, wind tunnel models, full scale mockups, and in general, any ground based models intended to assist design development, systems and components installation clarification, clearances establishment, etc.

1.9 FACILITIES

This element sums the facilities required to develop, produce and test the Orbiter Vehicle and ground systems or portions thereof. This element includes planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation, cost surveillance, records, and reporting.

1.9.1 ADMINISTRATIVE

This element refers to the facilities required to house administrative functions of the contractor(s) responsible for the Orbiter Vehicle & ground systems or parts thereof. This element includes: engineering, planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation cost surveillance, records, and reporting. Facilities include either modification of existing facilities, or new additions. They may be either at the contractor location, at subcontractors, or at Government installations. They encompass buildings, machinery, equipment, work stations, special purpose areas, unique test installations, or the like.

1.9.2 MANUFACTURING

This element refers to the facilities, either new or modified, required for the manufacture, assembly, and in process and acceptance checkout of the Orbiter Vehicle and ground systems or parts thereof. This element includes: engineering planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation, cost surveillance, records and reporting. Manufacturing facilities may be either at the contractor location, at subcontractors, or at Government installations. They encompass buildings, machinery, equipment, work stations, special purpose areas, unique test installations, or the like.

1.9.3 GROUND TEST

This element refers to the facilities, either new or modified, required for test of the Orbiter Vehicle and ground systems or parts thereof prior to acceptance by the Customer. This element includes: engineering, planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation, cost surveillance, records and reporting. It also includes the facilities for Orbiter Vehicle subsystems and Support Equipment testing, static, dynamic, environmental, drop tests, wind tunnel, laboratory testing, and generally encompasses any facility used for company-conducted development. It does not include any special test program tooling, fixtures, gauges, and instrumentation for specific tests which would be an element of the customer test program effort.

1.10 ORBITER SYSTEM SUPPORT EQUIPMENT & SERVICES

The orbiter system Support Equipment element sums all the effort and materials required to design, develop, and produce the hardware, software and services required to support the Orbiter Vehicle in all test and operational modes. This element includes: auxiliary, checkout, servicing, training, and handling and transportation Support Equipment; Spares and Standard Equipment items. It also includes training programs and aids, spares and Logistic management, and technical data in the form of handbooks and manuals, plus propellants and gases required in orbiter peculiar development programs (exclusive of flight tests). It does not include development or manufacturing costs for the Orbiter Vehicle system.

1.10.1 AUXILIARY EQUIPMENT

This element refers to auxiliary Support Equipment peculiar to the Orbiter vehicle, and also that equipment common between the Booster and Orbiter that is used to perform special operations or to fulfill special requirements in addition to the checkout, training, servicing, handling, and transportation equipment for the **Orbiter vehicle and its subsystems, components, controls, etc., during manufacturing, development ground and flight tests, and the** operational phases of the program. This element includes umbilical disconnect sets; physical (but not functional) simulator or substitute units for complete vehicles, subsystems, or components; ground power supplies; special tools; safing devices; etc. The design, development, inspection and production of such equipment is included in this element.

All costs for the design, manufacture and procurement of tooling required to produce the equipment are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations (operational phase) is excluded. Development test effort and equipment costs are included.

This element also includes the design, development, and manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.10.2 CHECKOUT EQUIPMENT

This element refers to checkout equipment peculiar to the Orbiter Vehicle, required in testing and checking out the Orbiter Vehicle and its subsystems, components, controls, etc., during manufacturing, development, ground and flight test and the Operational Phases of the Program. It includes equipment that is used to check out the Orbiter Vehicle during preflight for horizontal flight tests and during launch preparations, countdown, lift-off, and subsequent to return to Earth. It also includes checkout equipment peculiar to orbiter for the operational phase of the program. The design, development and production of such equipment is included in this element.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Development test effort and equipment costs are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include Support Equipment instrumentation requirements definition and installation design for both qualification and operational usage and is additional to the operational instrumentation configuration. The definition, design, procurement and installation of sensors/transducers for nonoperational instrumentation are also included.

1.10.3 HANDLING AND TRANSPORTATION EQUIPMENT

The handling and transportation equipment element refers to equipment peculiar to the Orbiter Vehicle, required to handle and/or transport the Orbiter Vehicle or portions of the Orbiter Vehicle system during manufacturing, development, ground and flight testing and operational phases of the program. This element includes the design, development and production of the equipment. It does not include equipment for assembling the payload module(s) into the payload container nor for loading the assembled payload (container) into the Orbiter Vehicle during pre-launch operations.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Development test effort and equipment costs are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include Support Equipment instrumentation requirements definition and installation design for both qualification and operational usage and is additional to the operational instrumentation configuration. The definition, design, procurement and installation of sensors/transducers for nonoperational instrumentation are also included.

1.10.4 SERVICING EQUIPMENT

This element refers to equipment, peculiar to the Orbiter Vehicle, required to service the Orbiter Vehicle and Support Equipment systems during manufacturing, development, ground/flight tests and operational phases of the program. This element includes: servicing equipment for, fueling of all propulsion subsystems, lubrication, landing gear maintenance, cabin and payload environment control, power systems, hydraulics, pneumatics, control systems, support equipment, etc. It also includes design, development and production of this equipment. It does not include any servicing equipment for the payload or maintenance of any special equipment that may be part of the payload.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Development test effort and equipment costs are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include support equipment instrumentation requirements definition and installation design for both qualification and operational usage and is additional to the operational instrumentation configuration. The definition, design, procurement and installation of sensors/transducers for nonoperational instrumentation are also included.

1.10.5 TRAINING EQUIPMENT

The training equipment element includes all equipment required for flight and ground crew training in preparation for and during the life of the Orbiter test and operations programs. This element includes design, development and fabrication of training equipment.

All costs for the design, manufacture and procurement of tooling required to produce the training equipment are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Development test effort and equipment costs are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and test of the basic equipment included in this element.

This element will also include Support Equipment instrumentation requirements definition and installation design for both qualification and operational usage and is additional to the operational instrumentation configuration. The definition, design, procurement and installation of sensors/transducers for nonoperational instrumentation are also included.

1.10.6 LOGISTICS OPERATIONS

This element includes identification of maintainability design criteria, identification of maintenance facility requirements, support & maintenance planning, support equipment control and modification planning.

It also includes the determination of spares candidates and the release of spares quantities, allocation, warehousing and transportation of spares as well as maintenance of spares status at each usage location, and the control of repairable items necessary to support the servicing and maintenance of the Orbiter and the associated support equipment during production and flight test.

1.10.7 TECHNICAL DATA

This element refers to the development, production, publication and distribution of all technical data (except training) required to operate, maintain and service the Orbiter Vehicle and Orbiter peculiar ground systems. Included are Orbiter peculiar flight and ground systems operations manuals (procedures) covering launch, mission and maintenance, and other direct Orbiter Vehicle support element manuals.

1.10.8 STANDARD SUPPORT EQUIPMENT ITEMS

The standard Support Equipment items element sums the procurement of all commercial equipment items, such as standard laboratory equipment, required to operate, maintain, or service the Orbiter System during the development production, and operational phases. This element includes inspection, and spare and repair parts.

This element also includes the effort required to analyze the characteristics, adaptability, and availability of GFE and Support Equipment used on other programs for use on the Shuttle program.

(Design and modification costs for the adaptation of Support Equipment from other programs are included in the applicable Support Equipment subsystem.)

1.10.9 PROPELLANTS AND GASES

This element includes that portion of Orbiter System propellants, gases, and fluids which are to be used in development testing and factory checkout. Propellants, gases, and fluids for flight test and operational phases are not included.

1.10.10 ON BOARD SUPPORT EQUIPMENT

This element refers to special equipment carried aboard (and not permanently installed), whose purpose is to: (1) evaluate, monitor, or assist in determining the performance adequacy of subsystems and components, or any intended improvement thereto; (2) provide more detailed fault isolation capability; or (3) provide peculiar support to certain payloads. It also includes design, development and production of such equipment. This equipment could be in the form of portable gauges, sensors, recorders, transmitters, cargo handling aids, etc. It does not include the Development Flight Instrumentation. Its operation during the mission cycle, and its removal after having served its purpose, does not in any way affect the normal operation of the Orbiter Vehicle and its systems.

This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

1.10.11 PRODUCTION SUPPORT

This element sums all of the level of effort type activities and products associated with Orbiter support equipment, but which are not identifiable to any specific hardware, other product, or service.

This element includes quality planning, usage type material, and manufacturing planning.

1.10.12 TRAINING SERVICES & AIDS

This element all effort and training material and aids required to develop and implement a training program for Orbiter System exclusive of the Shuttle system test and operational phase training described in WBS elements 4.3.4 and 5.5.2.

1.10.13 SUPPORT EQUIPMENT SOFTWARE

This element includes the design, processing and implementation of all Orbiter Support Equipment software (computer languages, computer programs, program verification, debugging, etc.,) for all elements of the Support Equipment. This includes all Ground Equipment programming effort for such activities to onboard checkout, data reduction and evaluation and Support Equipment Diagnostic Routines. The program performance specification, the program design specification, the detail subprogram design specification, the data base design specification, the program operating manual specification, the program test plans and test procedures specification, and the test program specification software requirements will be provided.

This element also includes the design, development, and implementation of spare software and associated data.

1.10.14 TRANSPORTATION

This element refers to the transportation of hardware containing more than one subsystem. Transportation of items containing only one subsystem is included within the specific subsystem. Transportation of the total vehicle from the manufacturing assembly facility to the flight test site are excluded and are contained in the Flight Test Ferry Operations element.

1.11 ORBITER MANAGEMENT

This is the Orbiter Program Management element. It includes the administrative and management activities which are "level of effort" in nature. This includes functions of contract administration, financial management, associate contract administration, configuration management, data management, program planning and scheduling, visibility reporting. This element also includes the Program Manager, Program Office, and direct reporting functional management.

Specific products include program master schedules, subsystem schedules, work packages, program reports, program management reviews, data publication and dissemination, change control documentation, configuration control documentation.

1.12 PAYLOAD

This element refers to the effort and materials required to design, develop and produce a habitable payload module which provides the capability for transporting up to ten passengers, and the interface items to be installed in the orbiter to accommodate a variety of payloads.

The activities required to integrate the still to be defined payloads into the orbiter are also included.

1.12.1 PAYLOAD INTERFACE PROVISIONS

This element refers to the effort and material required to design, develop, and produce the devices to provide the orbiter with the capability to interface with and transport a variety of payloads.

Included are the provisions for installation of standardized pallets for high frequency payloads, and for installation of extended mission capability kits such as auxiliary propulsion ΔV extension kit and 30-day mission expendables kit.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.12.2 HABITABLE PAYLOAD MODULE

This element refers to the effort and material required to design, develop, & produce a habitable payload which will provide the orbiter with a ten passenger transportation payload to and from orbit. Included are the structural container, hold down and docking devices, passenger life support systems, displays and controls, electrical power generation distribution and control, and communication systems.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

This element will also include vehicle instrumentation requirements definition and installation design for both flight qualification and operational usage. The definition, design, procurement and installation of sensors/transducers which are an integral part of this subsystem are also included.

1.12.3 PAYLOAD INTEGRATION

This element refers to the engineering activities required to assist in one definition of interface requirements between the orbiter and payloads to be defined for the operational missions. It includes the definition of payload handling procedures, design and schedule requirements, from user inquiry through mission completion and data analysis. Special emphasis will be given to orbiter configuration control and payload weight management. This activity will support the mission/operations analysis to be conducted under 1.8 System Engineering & Integration.

2.0 MAIN ENGINE

This element of the WBS refers to the main engine which is provided as GFE for common usage in both Vehicles. This element includes, for example, pre-burner(s), propellant feed inducers, high speed centrifugal pumps, turbo-pumps, thrust vector controls interface fittings, gimballing, servomechanisms, and the like. It covers the design, development, and production of the main engine and these typical components. It does not include any tankage nor pressurization system.

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3.0 BOOSTER

The Booster element sums all lower level elements identifiable and peculiar to the Booster System including all vehicle subsystems; mockups and models; integration, assembly checkout of the vehicle; subsystem tests; facilities for administration, manufacturing and test; system support including handling, checkout and servicing equipment, Booster peculiar and standard support equipment, ground tests propellants and gases, training and training equipment, provisioning, and technical data; and the program management elements of contract management, configuration management, program documentation, and program planning and control.

The effort includes all Booster peculiar design, development, production and support.

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3.1 STRUCTURAL SUBSYSTEMS GROUP

This element sums all of the effort and materials required to design, develop and produce the primary and secondary structural systems which comprise the basic booster vehicle structure. The lower indenture levels of this element include body structure, fixed and movable aerodynamic surfaces and thermal protection.

3.1.1 BODY STRUCTURE

The body structure element refers to the fuselage structure of the booster vehicle. This element includes primary structural items such as the main propellant tankage, thrust complex, base heat shield, crew compartment, and intertank adapter. It also includes supporting structures that are nonseparable from the assembled structure such as wing and empennage attachment fittings, wing and landing gear support bulkheads, and orbiter support fittings. The mating/separation system is also included in this element. Secondary structure such as access panels, doors, and supporting structure for the attachment of nonstructural subsystems is also included. The TPS cover panel support structures (frames and stringers) are excluded from this element.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.1.2 AERODYNAMIC SURFACES

The aerodynamic surfaces element refers to all primary lifting and aerodynamic control surfaces, both fixed and movable, of the booster vehicle. This element includes such items as the wing, empennage, and canard, including leading and trailing edge structures, and associated control surfaces such as flaps, rudders and spoilers. Also included in this element are thermal protection insulation, cover panels and all attachment structure, integral tanks and access panels, as well as doors and nonseparable attachment structure for wing-mounted flyback engines. Specifically excluded from this element are aerosurface-mounted systems such as nonintegral tanks; propellant feed, drain, and vent lines; and hydraulic lines, valves, and actuators.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.1.3 THERMAL PROTECTION SYSTEM (TPS)

The TPS element refers to the external structure which protects various booster body regions from the high temperature environment during ascent and entry. These TPS regions include such areas as the nose, basic body (surrounding fuselage structure), canard fairings, and external propellant line fairings, but exclude any areas on the aerosurfaces (e.g., leading edges), wing belly cover panels, and exposed portions of the thrust complex or base heat shield. This element includes items such as the heat shield cover panels, cover panel support structure (frames, etc.), cover panel insulation, and attachments.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operationsl sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.1.4 LANDING SYSTEM

The landing element refers to the vehicle mounted devices required to support and cushion the Booster Vehicle for horizontal takeoff and landing. This element includes, main landing gear, nose landing gear, linkages, latches, etc. It specifically excludes the hydraulic actuators which operate the landing gear mechanism. The actuators are included in the Hydraulic Power Subsystem element.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.2 PROPULSION SUBSYSTEM GROUP

This element sums all of the effort and materials required to design, develop, produce and/or integrate the primary and secondary propulsion subsystems into the booster vehicle. As such it includes the main rocket, airbreathing and attitude control systems. It specifically excludes main rocket engine design, development and production.

3.2.1 MAIN PROPULSION

The main propulsion element refers to the Booster Vehicle main rocket engine subsystem. This element includes all propellant feed system elements between the engine interface and the propellant tankage interface. This element includes items such as lines, valves, regulators, controls, etc. This element also includes the tank vent and pressurization system and the engine pneumatic system. It does not include the cryogenic tankage.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activites (excluding activities performed at the test or operational sites) are also included. The design, manufacture, and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations element.

3.2.2 ATTITUDE CONTROL

The attitude control propulsion element refers to the Booster Vehicle propulsion subsystem which provides the capability for small three-axis translational maneuvers and three-axis attitude control. This element includes thrusters, propellant distribution manifolds, gas and liquid storage tanks and accumulators, heat exchangers, heat transfer coils, pressure regulators, propellant feedlines and distribution networks, pumps, gas generators, valves, sensors, probes, etc.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.2.3 AIR-BREATHING PROPULSION

The air-breathing propulsion element refers to the Booster Vehicle propulsion which provides capability for (1) short-duration powered descent after entry, (2) powered landing approach and go-around, and (3) ferry flight between airports. This element includes jet engines, nacelles, deployment devices, starters, propellant feed systems, other engine accessories and propellant tankage.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.3 AVIONICS SUBSYSTEM GROUP

This element sums all of the effort and materials required to design, develop and produce all items comprising the avionics subsystem and integrating these into the booster vehicle. The lower level elements include GN&C, data control and management, software, displays and controls, and communications. Included in this element are all prototype, development, production, test and support articles including spares and repair parts, and design and fabrication of mockups.

3.3.1 GUIDANCE, NAVIGATION AND CONTROL (GN&C)

The GN&C element refers to the Booster Vehicle subsystem which performs navigation, guidance and flight control functions. This element includes such items as: drive/pickoff electronics, radar altimeter, ILS and marker beacon, aero surface servo amplifiers, ACPS valve drivers, thrust vector servo amplifiers, IMU strapdown hexad, flight control computer, flight control computer main memory.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards and the design, manufacture and maintenance of tooling. Manufacture of spares and parts repair is also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.3.2 DATA CONTROL AND MANAGEMENT (DCM)

The DCM element provides Booster Vehicle automated control and system/subsystem management for multimission capability. This element includes, memory complexes, ACT (Acquisition, Control and Test) units, data management computer, data bus control, mass memory control unit, main data bus, sensors, etc.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair is also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.3.3 DISPLAYS AND CONTROLS

The displays and controls element refers to displays and controls located at the Booster Vehicle flight crew station. This element includes, multiformat CRT display, alphanumeric display and buffer, caution and warning, manual flight controls and buffer, multifunction flight controls and buffer, sensors, etc.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair is also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.3.4 COMMUNICATIONS

The communications element refers to the Booster Vehicle subsystem which provides two-way voice and data transmission and ranging retransmission. This element includes, antennas, VHF/AM transceiver, signal processor, flight log recorder, sensors, etc.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair is also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operations. This effort is included in the Flight Test and Operations elements.

3.3.5 SOFTWARE

This element includes the design, processing and implementation of all booster software (computer languages, computer programs, program verification, debugging, etc.), for all elements of the ground and airborne subsystems. Shuttle program airborne and ground systems software development, maintenance and change control throughout the operational program are included. The software program performance specification, design specification, detail subprogram design specification, data base design specification, program operating manual specification, programs test plans and test procedures specification, and the test program specification software requirements are included.

3.3.6 INSTRUMENTATION SUBSYSTEM

This element comprises the activities required to provide a Booster Vehicle operational instrumentation subsystem including establishment of general instrumentation requirements criteria for all interfacing vehicle subsystems, and ground subsystems. Included is the definition, specification preparation, installation design, acquisition, and test for all requirements including on-board recorders, central timing equipment, telemetry format generators, signal conditioning/buffering equipment and end item sensors which are not integral to a using subsystem.

The activities required to provide a Development Flight Instrumentation (DFI) system are also included. The DFI includes a DFI format controller, recorders, DFI controls and displays, DFI acquisition and signal conditioning units, and Frequency Modulation units. Included is the definition, specification preparation, installation design, acquisition, and test for all DFI requirements.

Design, fabrication, and operation of mockups, breadboards, and simulators is included. All costs for the design, manufacture and procurement of tooling required to produce the common operational instrumentation and the DFI are included. The maintenance of tooling during production and flight test is included, but tooling maintenance during the flight operational period is excluded. Subsystem development test and equipment are included. This element also includes inspection.

3.3.6 INSTRUMENTATION SUBSYSTEM (Continued)

This element also includes the design, development, and manufacture of spares and repair parts in support of production, flight test, and operations.

3.4 POWER GROUP

This element sums all of the effort and materials required to design, develop and produce the auxiliary power unit and those vehicle subsystems which provide hydraulic and electrical power generation, distribution and control.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.4.1 AUXILIARY POWER UNIT

The auxiliary power unit element refers to the prime power source for all Booster Vehicle subsystems. This element provides the power to drive the hydraulic pumps and electrical generators. It does not include electrical or hydraulic power generation, control, and distribution subsystems.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.4.2 HYDRAULIC POWER GENERATION, DISTRIBUTION AND CONTROL

The hydraulic power element refers to the mechanical system required to actuate powered, movable devices in the booster vehicle. These devices consist of flaps and spoilers, control surfaces, engine gimbal actuator system, landing gear, and separation system. This element includes hydraulic pumps, accumulators, actuators, regulators, lines, and valves. The element specifically excludes those devices which are controlled (surfaces, engines, gear, etc.).

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair activities (excluding activities performed at the test or operational sites) are also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.4.3 ELECTRICAL POWER GENERATION, DISTRIBUTION AND CONTROL SUBSYSTEM

The electrical power generation, distribution and control subsystem element refers to the subsystem which generates, distributes and controls electrical power to all Booster Vehicle subsystems. This element includes, power buses, inverters, transformer-rectifiers, battery charger, power control, and protection units, electrical connectors, electrical cables for vehicle signal and power, generator control units, lighting, interlocks, and sensors. It does not include computer functions concerned with electrical power control and energy management. It includes all design, development and production of complete units, or intact subassemblies installable in the Booster Vehicle. Design, operation and fabrication of mockups, simulators and breadboards are included. Test activities will include laboratory simulators.

All costs for the design, manufacture and procurement of tooling required to produce the subsystem are included. The maintenance of tooling during production and flight test is included, but maintenance during flight operations is excluded. Subsystem development test and equipment are included. This element also includes inspection.

This element also includes the design, development, manufacture of spares and repair parts in support of production and flight test of the basic equipment included in this element.

Special consideration will be given to safety criteria and reliability objectives.

3.5 ECLS GROUP

This element sums all of the effort and materials required to design, develop and produce those booster vehicle subsystems which provide life and equipment conditioning and personnel provisions. The lower level elements include environmental control and life support and flight personnel provisions.

3.5.1 ENVIRONMENTAL CONTROL & LIFE SUPPORT (ECLS)

This element refers to the equipment required to provide thermal control for the crew, crew compartment, and electrical equipment; to control cabin pressure; and to satisfy crew metabolic requirements. The subsystem will eventually provide additional thermal control for remote equipment and bays as these requirements become identified. This element also includes the interstitial purge system required to purge the interior body cavities (external to the propellant tankage) of potentially hazardous gases.

Work effort includes engineering design and development parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair is also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.5.2 FLIGHT PERSONNEL PROVISIONS

The flight personnel provisions element refers to the Booster Vehicle equipment/mechanisms/supplies required to enable the flight crew to perform their mission functions. This element includes, crewman couches/seats, harnesses, stationary items, etc.; it does not include items listed under displays and controls and ECLSS elements.

Work effort includes engineering design and development, parts manufacturing and subassembly, quality control, inspection, and procurement activities to provide all ground test, flight test, and production articles. Also included is the design and manufacture of subsystem mockups and breadboards. Manufacture of spares and parts repair is also included. The design, manufacture and maintenance of tooling is included.

The installation and assembly of this subsystem into the booster vehicle is excluded. This effort is included in the Installation, Assembly, and Checkout element. Also excluded is the maintenance effort required at the test and operational sites in support of flight operations. This effort is included in the Flight Test and Operations elements.

3.6 BOOSTER VEHICLE INSTALLATION, ASSEMBLY, AND CHECKOUT

This element sums all of the tasks related to the installation, assembly, and checkout of functional equipment in the Booster Vehicle (flight and major ground test articles, operational vehicles, and vehicles recycled for recertification or modifications). It includes the installation/assembly of subsystems, assemblies, components, controls, etc., into major Booster Vehicle structural modules and assembly of these modules into a Booster Vehicle. These activities include primary and final assembly and checkout operations and attendent quality control, inspection, production test, and checkout operations. The design, fabrication, and maintenance of tooling and fixtures required to accomplish this activity and maintenance of factory GSE and test equipment (exclusive of spares and repair parts) are also included. GSE and test equipment spare and repair parts costs are included in WBS 3.10.1.

3.6.1 PRIMARY ASSEMBLY

This element refers to the effort of installation and initial checkout of subsystems (pneumatic, hydraulic, electrical, etc.) components into the wing, body and tail structure. Specifically excluded is the installation of wiring, ducts, lines, etc. which are installed into the wing, tail, crew cabin, and canard under the specific WBS element.

Work effort includes: tool design and manufacture of assembly and tools/fixtures, and associated manufacturing aids to support primary assembly; factory operations including wing primary, tail primary, body primary, canard primary, plant engineering assist; and associated quality control. Also included in this element is all production planning and procedures associated with the primary assembly operations.

Final Assembly (mating of wing, tail, canard, etc.) is excluded. This effort is included in the Final Assembly element.

3.6.2 FINAL ASSEMBLY

This element refers to the effort of mating the Wing, Tail, TPS, and Canard to the Body structure and installation of the major subsystems such as engines, flight controls, crew provisions, avionics subsystem, etc.

Work effort includes: tool design and manufacture of assembly and mating tools/fixtures and associated manufacturing aids to support mating and final assembly activities; factory operations including mating and subsystem installation, plant engineering assist, and associated quality control. Also included in this element is all production planning and procedures associated with the Final Assembly operations.

Activities associated with removal of components/hardware following checkout, in preparation for transportation to the flight test site, are also included.

3.6.3 CHECKOUT

This element refers to the effort associated with checkout of the completed Booster Vehicle involving verification of the physical and functional validity of the subsystem installations and the integration of multiple subsystems in their proper integration sequence (prior to turnover for flight test operations).

Work effort includes preparation of checkout procedures, conduct of the checkout operations, and data reduction and evaluation. Also included is support activities such as quality control.

3.7 COMBINED SUBSYSTEM DEVELOPMENT TESTING

This element includes all the effort and support materials and services required to perform tests involving two or more subsystems independent of or in conjunction with booster support equipment. It includes all integrated subsystems test planning, test operations, instrumentation and test fixtures; but specifically excludes vehicle test hardware and propellants and gases. Supporting services include such functions as maintenance of test article, facility, GSE and test equipment; shop support, security, supply operations, standards laboratory, etc. It does not include flight tests or major ground tests in support of or preparation for flight tests.

3.7.1 MAIN PROPULSION TEST PROGRAM

This element refers to the effort to plan, conduct and evaluate the main propulsion cluster test program using the propulsion test vehicle (PTV). The test program consists of a series of cryogenic tankings and static firings using all main propulsion system elements in conjunction with their associated subsystems. All instrumentation, test fixture, and software design fabrication, and installation which is peculiar only to the test program is included.

3.7.2 AVIONICS/NON-AVIONICS TEST PROGRAM

This element encompasses the effort and support required to conduct integration of the Avionics Subsystems Group with the Structural, Propulsion, Power, ECLS, and Systems Support Groups. This activity will take place in an Avionics Systems Integration Laboratory (ASIL), where actual avionics and software will be interfaced with computer models/simulations of the non-avionics subsystems. It includes all test operations, data evaluation and reporting, and instrumentation calibration.

3.7.3 SEPARATION SYSTEM TEST PROGRAM

This element refers to the effort and support required to plan, conduct, and evaluate the stage separation dynamic test program using the following major vehicle assemblies; the static structural test assembly comprising the LH_2 tank, intertank adapter, thrust barrel, fwd. and aft attachment and the separation links. Simulation of actual loads, operations and separation sequencing will be performed. All instrumentation and test fixture design, fabrication and installation which is peculiar only to the test program is included. The element includes all test operations, data evaluation and reporting.

3.7.4 ATTITUDE CONTROL PROPULSION SYSTEM - ELECTRICAL/MECHANICAL POWER GENERATION TEST PROGRAM

This element refers to the effort and support required to plan, conduct, and evaluate the attitude control propulsion system - electrical/mechanical power generation test program using the following major components: the ACPS tanks, thrusters, gas generator, and the auxiliary power unit, hydraulic pump, and electrical generator. This element includes all test rigs, fixtures, set-ups, and the design, fabrication, installation and calibration of test instrumentation. This element also includes all test operations, data evaluation and reporting.

3.7.5 ENVIRONMENTAL CONTROL AND LIFE SUPPORT TEST PROGRAM

This element refers to the effort and support required to plan, conduct, and evaluate the environmental control and life support test program, using the following major vehicle assemblies: the crew cabin used in the structural subsystem testing, avionics racks, and the ECLS system. This element includes all test rigs, fixtures, set-ups, and the design, fabrication, installation and calibration of test instrumentation. This element also includes all test operations, data evaluation and reporting.

3.7.6 CREW ESCAPE SLED TEST

This element refers to the effort and support required to plan, conduct and evaluate the crew escape system using a sled test program. It includes test rigs, fixtures, set-ups, and the design, fabrication, installation and calibration of test instrumentation. The element also includes all test operations, data evaluation and reporting.

3.8 BOOSTER SYSTEM ENGINEERING AND INTEGRATION

This element refers to the effort of directing and controlling a totally integrated engineering effort encompassing system engineering, aero-thermodynamics and related wind tunnel development testing, design engineering, support engineering, production engineering and specialty fields such as reliability, maintainability, system effectiveness, safety, human factors, and the like. This element includes: system definitization, system design, design integrity analysis, system optimization, cost effectiveness analysis, weight and balance analysis, and intra-system and inter-system compatibility analysis. It also includes reliability, maintainability and safety requirements, human engineering and manpower factors program, preparation of equipment performance specifications, logistics support integration, and design of test and demonstration plans. Activation of the necessary administrative, manufacturing and ground test facilities are also included.

This element also refers to models and mockups of the Booster Vehicle or major portions thereof involving two or more subsystems. This includes scale models, wind tunnel models, cabin models, full scale mockups, and in general, any ground based models intended to assist design development, systems and components installation clarification, clearances establishment, etc. This element includes design and fabrication of the above mockups and simulation devices. They may include dummy subsystems or components and be either static or dynamic.

3.8.1 SYSTEMS ENGINEERING

This element refers to the effort to define and allocate engineering requirements necessary to direct and control an integrated approach to design, development and operations. It includes the functional areas of design, performance technologies, human factors, abort, and wind tunnel testing.

The systems engineering design program encompasses system definition including requirements definition, mission/payload analysis, preliminary design, design integration, system optimization, interface compatibility, design reviews, technical risk assessment, technical performance measurement, countdown analysis, and system engineering data.

The human factors study includes the principles and application related to the areas of human engineering, training, life support, environmental control, safety, habitability, hazards, etc., to insure booster and ground system designs are within all the parameters of biomedical and psychosocial considerations.

The intact abort analysis (orbiter and booster abort separation and landing) will include abort requirements, procedures, flight mechanics analyses, operations definition for all mission phases on flight and groundbased hardware, abort hardware/software requirements, training requirements, and cost effectiveness tradeoffs.

3.8.1 SYSTEMS ENGINEERING (Continued)

This element also includes analyses and studies to establish vehicle performance for the design reference and other missions, to define vehicle configuration, and to support the design and development of the booster vehicle. Analytical disciplines included are flight mechanics, configuration aerodynamics, stability and control, air loads, aerothermodynamics, static and dynamic loads, stress propulsion, fracture control, and noise as well as associated simulations and mathematical modeling.

Wind tunnel testing will be conducted to support design, development, verification and refinement of the booster and mated vehicles.

Activation of the necessary administrative, manufacturing and ground test facilities are also included.

3.8.2 INTEGRATION

This element refers to (1) the inter-system engineering interface tasks which include maintaining relationships with other Space Shuttle contractor, subcontractors, and also with NASA and other government agencies, and (2) the intra-system engineering interface tasks within the booster contractor organization. The booster vehicle and ground system interfacing elements will be defined, integrated and documented by Interface Control Documents (ICD), Joint Operating Plans and Interface Control Plans. Specialty disciplines such as the program plans and analyses for quality control, reliability, maintainability, producibility, transportability, safety, and logistics will be developed. Also included is the mass properties control program to insure booster weight and other mass properties constraints are not exceeded.

3.8.3 MODELS AND MOCKUPS

This element refers to the design and fabrication of wind tunnel test models, and full scale mockups for demonstrating and identifying problem areas in the arrangement of subsystem installations.

The subscale wind tunnel models include designs for aerodynamic type tests, aero-thermodynamic testing, and aeroelastic and flutter testing. Model scales will allow maximum utilization of NASA controlled facilities, considering data requirements, potential alternate facilities and utilization. The models will include both powered and unpowered configurations.

Specific mockups to be provided include the crew compartment, aft fuselage, air breathing engine installation, intertank area, avionics compartment, and the landing gear. They may include dummy subsystems or components and be either static or dynamic.

3.9 FACILITIES

This element sums all of the effort and materials required to provide facilities needed to develop, produce, test, and administer the Booster Vehicle system or portions thereof. This element includes planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation and tryout, cost surveillance, records and reporting. Lower level elements include administrative, manufacturing, and ground test facilities.

3.9.1 ADMINISTRATIVE

This element refers to the facilities required to house administrative functions of the contractor(s) responsible for the Booster Vehicle system or parts thereof. This element includes, engineering, planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation and tryout, cost surveillance, records, and reporting. Facilities include either modification of existing facilities, or new additions. They may be either at the contractor location, at subcontractors, or at Government installations. They encompass buildings, machinery, equipment, work stations, special purpose areas, unique test installations, or the like.

3.9.2 MANUFACTURING

This element refers to the facilities, either new or modified, required for the manufacture and assembly of the Booster Vehicle system or parts thereof. This element includes, engineering, planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation, cost surveillance, records, and reporting. Manufacturing facilities may be either at the contractor location, at subcontractors, or at Government installations. They encompass buildings, machinery, equipment, work stations, speical purpose areas, unique test installation, or the like.

3.9.3 GROUND TEST

This element refers to the facilities, either new or modified, required for test of the Booster Vehicle system or parts thereof prior to acceptance by the Customer. This element includes engineering, planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation, cost surveillance, records and reporting. It also includes the facilities for Booster subsystems testing, static, dynamic, environmental, drop tests, wind tunnel, laboratory testing, and generally encompasses any facility used for company-conducted development.

3.10 SYSTEM SUPPORT EQUIPMENT AND SERVICES

The Booster system support element sums the hardware, software, and services required to support the Booster Vehicle in the test and operational mode, and also includes the procurement of ground support equipment (GSE) and test equipment hardware required for production, test, and the operational phases. This element includes: new and standard support equipment, training equipment and programs, spares logistics management, and technical data in the form of handbooks and manuals, etc. It also includes procurement of propellants and gases required in booster peculiar development programs (exclusive of flight tests) and transportation of hardware containing more than one subsystem.

3.10.1 SUPPORT EQUIPMENT (PECULIAR)

This element sums the support equipment which is designed specifically for the Booster Vehicle. This element includes: launch support equipment, checkout equipment, handling and transportation equipment, servicing equipment, test equipment and training equipment. This element consists of the design, development test (where tested separately from other subsystems), and manufacture of this equipment for factory, test and operational sites; and the procurement of spares and repair parts (S&RP) for this equipment during all program phases.

3.10.2 STANDARD SUPPORT EQUIPMENT ITEMS

The standard support equipment element includes procurement of support equipments not specifically designed or produced for the Booster system but which are required to operate, maintain or service the Booster vehicles or ground systems during all phases of the program. Included herein are such items as current inventory equipment capable of being produced to existing design data. This element also includes procurement of spares and repair parts (S&RP) for this equipment in support of all program phases.

3.10.3 TRAINING AND TRAINING AIDS

This element consists of training services, training materials, and training aids required for Booster flight and ground crew training. It includes instructor and student services, lesson plans, study guides, training manuals, and training aids for classroom and trainer instruction in preparation for and during the Booster test program.

3.10.4 LOGISTICS OPERATIONS

This element refers to the management of spares and repair parts and other specialized logistics support of the Booster system during development. This element includes the determination and management of spares quantity, procurement, warehousing, distribution and transportation. It also includes maintenance of spares status and logistics of repairable items to support servicing and maintenance of the Booster Vehicle and Booster support equipment during development. The cost of spares and repair parts (S&RP) and rework costs are not included.

3.10.5 TECHNICAL DATA

This element refers to the development, production, publication and distribution of technical data required to operate, maintain and service the booster vehicle and booster peculiar ground systems prior to the operational phase. Included are initial development, modification and production of booster peculiar flight and ground systems operations manuals (procedures) covering launch, maintenance, mission operations, and other direct booster vehicle support element manuals.

3.10.6 PROPELLANTS & GASES

This element refers to the production or procurement, delivery, and usage of propellants and gases required for booster subsystem and combined subsystem testing and booster peculiar GSE and facilities development. Propellants and gases for flight tests and operational phase are not included.

3.10.7 TRANSPORTATION

This element refers to the preparation for and transportation of major items of equipment and hardware containing two or more subsystems. Transportation of items containing only one subsystem is included within the specific subsystem. Transportation of the total Booster Vehicle from the manufacturing assembly facility to the test sites is included in this element.

3.11 BOOSTER MANAGEMENT

This element covers the effort required for direction and control of the development of the entire Booster System. The lower level elements include contract management, program planning and control, configuration management, program documentation, and financial and manpower control. Work efforts include direction and control of all functional program organizations and primary interface with the customer and associate contractors. Also included are the management of such activities as material management, and other project and functional management activities not included in other WBS elements.

3.11.1 CONTRACT MANAGEMENT

This element refers to those activities which monitor, direct and control the overall program, assure resolution of problem areas, and interface with the cognizant NASA Project Office. Data items prepared and submitted under this element include the program organization structure, organization responsibilities, and management planning. The element includes the Program Manager, Program Office, and direct reporting functional management. These administrative and management activities are "level of effort" in nature.

3.11.2 PROGRAM PLANNING AND CONTROL

This element refers to those activities required to schedule the overall Booster Vehicle program. It includes the development of schedule requirements by establishing and maintaining a Master Program Schedule. The schedule will portray significant milestones necessary to measure, analyze, and highlight problem areas, both potential and existing. The element also includes program status and conference requirements through the integration of schedules with the technical and manufacturing efforts, data collection, analysis and reporting.

3.11.3 CONFIGURATION MANAGEMENT

This element refers to the overall Booster Vehicle System configuration management processes and activities, It will provide program change control and configuration accounting, and will maintain CCB and ICD requirements. Baseline reviews will be provided as required. Specific tasks accomplished by this element include (1) the establishment and maintenance of the Configuration Management Plan, (2) establishment, implementation, and maintenance of specification formats, end item selection criteria, procedures for control and accounting of configuration and changes, (3) configuration management design support, reviews, audits, and analysis, and (4) collection, analysis and reporting of the appropriate configuration management data. Configuration verification documentation will be provided for Booster Vehicle acceptance.

3.11.4 PROGRAM DOCUMENTATION

This element refers to the overall Booster Vehicle Systems data management process and activities required to ensure a program documentation system conforming to the Contract Documentation Requirements Document. It includes the establishment, implementation, and maintenance of the data management plans and procedures as well as accumulation and submission of the required data.

3.11.5 FINANCIAL AND MANPOWER CONTROL

This element refers to the overall Booster Vehicle System management process and activities required to provide program financial and manpower control. It includes the establishment and implementation of methods for planning, control and performance measurement of financial data. Development, preparation and maintenance of manpower requirements by major organizational elements and by site location along with projections and forecasts is also included.

4.0 FLIGHT TEST

This element sums all activities, facilities and Supporting Equipment and services associated with the development flight testing of the orbiter, booster and mated Shuttle vehicles. It includes ground tests in support of flight tests, flight tests, equipment, checkout and test procedures, test plans and manpower necessary for the performance of these tests, analysis and evaluation of test results, reports, and management of the overall test operations.

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4.1 ORBITER VEHICLE TEST

This element sums all effort and materials required for flight and ground testing of the Orbiter Vehicle as a single element subsequent to manufacturing acceptance checkout. This element includes pre-ferry preparations, flight test ferry operations, horizontal flight test operations, maintenance and refurbishment, mission planning and simulation, and support services.

4.1.1 PRE-FERRY PREPARATION

This element represents the ground testing performed at the manufacturing site following completion of Orbiter integrated checkout. This element includes planning and scheduling, test procedure preparation, pre-ferry ground preparation, taxi tests, limited flight tests to demonstrate airworthiness prior to ferry flights, data acquisition and reduction, test reports, and Support Equipment verification as required. It also includes the personnel directly involved in the actual conduct of ground tests and integration of the Support Equipment.

4.1.2 FLIGHT TEST FERRY OPERATIONS

This element consists of all the effort and materials required to support ferry flights of the orbiter to the test site from the manufacturing assembly facility and from the test site to the operational site. It includes all the service and materials required for servicing the vehicles after landing and for preparation of the vehicle for ferry exclusive of M&R services and materials (e.g., safing and detanking) which are part of Orbiter elements 4.1.3 and 4.1.4. Transportation of special equipment to landing sites is included.

4.1.3 HORIZONTAL FLIGHT TEST OPERATIONS

Horizontal Flight Test Operations includes those services, activities, and materials in direct support of the single element horizontal flight test program for the Orbiter beginning with arrival at test site and ending with start of pre-ferry preparations. Included in this element are the flight test support activities such as test planning, scheduling, preparation of test procedures, support equipment integration, test reports, data analysis, data processing, and ground based support activites such as preflight preparations, command, control, tracking, and communications. All consumables (with the exception of spares and repair parts, propellants and gases) are included.

4.1.4 MAINTENANCE AND REFURBISHMENT

This element includes those activities and materials necessary to refurbish and maintain the Orbiter vehicle in an operable condition during the horizontal flight test program. This effort includes support equipment integration, test procedure preparation, planning and scheduling vehicle(s) post flight safing and inspection, materials (excluding spares and repair parts, propellants and gases) necessary for servicing and restoration of any element of the Orbiter system, and the maintenance of Orbiter peculiar test equipment, GSE and facilities.

4.1.5 MISSION PLANNING & SIMULATION

This element refers to those activities associated with mission planning, conducting simulated missions, and the required computer programming services in direct support of the Orbiter horizontal flight test program.

4.1.6 SUPPORT SERVICES

This element representing the effort and material required to support the orbiter vehicle test. It includes logistics support, training, human factors and safety, quality/reliability, propellants, gases and other consumables required for the orbiter vehicle test.

4.2 BOOSTER VEHICLE TEST

This element sums all labor, materials and services required to flight and ground test the Booster Vehicle as a single element. Planning, scheduling, checkout and test procedure preparation, test conduct, data reduction and analysis, and test report preparation are included. Costs of flight test vehicles and the associated vehicle and support equipment spares and repair parts (S&RP) are not included. These S&RP costs are included in the applicable vehicle subsystem (WBS 3.1 through 3.5) and support and test equipment (WBS 3.10) elements.

4.2.1 PRE-FLIGHT OPERATIONS

This element includes the ground development testing performed on the Booster vehicle in preparation for single element flight tests. This element includes planning, scheduling, checkout and test procedure preparation, conduct of tests, support, data reduction and analysis and test report preparation prior to first flight. Specific inclusions are: (1) Ground testing in support of flight testing; (2) Checkout and integration of supporting GSE; (3) Transportation of vehicle to launch site; (4) Vehicle subsystems prelaunch checkout; (5) Integrated systems test; (6) Load operations, and (7) Engine run and taxi tests.

4.2.2 HORIZONTAL FLIGHT TEST OPERATIONS

The operations and services element includes those activities and materials in direct support of flight test of the booster in the single element flight mode. Included in this element are the flight test support activities such as individual flight planning, scheduling preparation of flight test procedures, preparation of test reports, data reduction, processing and analysis, ground based command control tracking and communications activities and the use of chase and support aircraft.

4.2.3 MAINTENANCE AND REFURBISHMENT

The maintenance and refurbishment element consists of maintenance and technician personnel and materials necessary to maintain the booster vehicles and associated GSE, test equipment and facilities in an operable condition during the booster single element flight test program. This effort includes vehicle(s) post-flight safing and inspection, vehicles/subsystems maintenance and refurbishment, installation of test fixtures and instrumentation, and maintenance planning and scheduling. Materials included in this element are limited to the consumables (excluding spares and repair parts, propellants and gases) necessary for servicing and restoration of any element of the booster system (including test fixtures and instrumentation, GSE, and test equipment).

4.2.4 MISSION PLANNING AND SIMULATION

Mission planning is covered under element 4.2.1; mission simulations and associated computer services under 3.8.1.

4.2.5 SUPPORT SERVICES

This element refers to the propellants and gasses and other consumables required to support the Booster Vehicle horizontal test program.

Logistics support is covered under 3.10.4. Training is covered under 3.10.3. Human factors, safety, and quality/reliability is covered under 3.8.2.

4.3 SHUTTLE SYSTEM TESTING

This element sums the manpower and materials required for the Shuttle Vehicle tests performed at the operational site and in support of the flight test mission. This element includes Ground and Flight Operations and Services, Maintenance and Refurbishment, Mission Planning and Simulation, and Support Services.

4.3.1 FERRY OPERATIONS

This element includes all the effort and materials required to perform ferry operations of the orbiter and/or booster from alternate landing sites to the M&R facility. It is limited to the manpower and materials required for the preparation of the vehicles for ferry, the ferry flight, in-transit support through landing, and delivery to the M&R facility. This element excludes the services and materials provided at the alternate site(s) by the M&R function (e.g., safing and detanking). Transportation of special equipment and personnel to alternate landing sites is included.

4.3.2 GROUND OPERATIONS AND SERVICES

This element includes all the manpower and materials necessary for the pre-mate checkout, planning and scheduling, test procedure preparation, support equipment integration, Payload Installation and Interface Verification, Orbiter/Booster Erection and Mating, Mated Transport to the pad, all pad prelaunch operations and systems checkout through countdown and launch. Excluded from this element are the payload materials (propellants, cargo, etc.), and the consumables required to prepare for and launch the shuttle vehicle.

4.3.3 FLIGHT OPERATIONS AND SERVICES

The Flight Operations and Services element for the mated system includes those activities and materials necessary to conduct the actual flight test of the Orbiter and Booster when launched in the mated configuration from lift-off to touchdown at the landing site. Included in this element are the flight test support activites such as test planning, scheduling, preparation of test procedures, test reports, data analysis, data acquisition and processing, and the ground based support activities such as command, control, tracking and communications required to support the above-described flight tests. All consumables (with the exception of spares and repair parts, propellants and gases) are included.

4.3.4 MAINTENANCE AND REFURBISHMENT

This element includes those activities and materials necessary to refurbish and maintain the booster and orbiter vehicles in an operable condition during the life of the shuttle vehicle flight test program. This effort includes planning and scheduling, test procedure preparation, support equipment integration, vehicle(s) postflight safing and inspection, booster and orbiter storage. Materials included in this element are limited to the consumables (excluding spares and repair parts, propellants and gases) necessary for servicing and restoration of any element of the shuttle system, and the maintenance of test equipment, GSE and facilities.

4.3.5 MISSION PLANNING AND SIMULATION

This element refers to those activities associated with mission planning, conducting simulated missions, and the required computer programming services in direct support of the mated systems flight test program.

4.3.6 SUPPORT SERVICES

This element represents the effort and material required to support Shuttle System Testing. It includes logistics support, training, human factors and safety, quality/reliability, propellants, gases and other consumables required for Shuttle System Testing.

4.4 FACILITIES

This element refers to all the test facilities required to develop, operate, control and recover the Space Shuttle vehicles during the Developmental Flight Test Program. It includes the required facilities to launch, operate and control the flight, recover, maintain, service and checkout the orbiter and booster during the horizontal and mated launch phases of the test program. It also includes the design, construction, activation activities and the personnel requirements to operate and support each facility for the duration of the Development Flight Test Program.

4.4.1 LAUNCH FACILITY

This element refers to the operational phase facilities required during the Development Flight Test Program for shuttle vehicle pre-launch and launch operations. This element includes, for example: facilities for propellant loading, flame trench, service elevator, and taxi strip paving from M&R facility to launch pad. It includes engineering, planning, design, and layout, negotiating subcontracts, monitoring procurement, construction, installation, activation, cost surveillance, records and reporting. It does not include facilities at alternate landing sites or mission support facilities.

Activation refers to the effort required to achieve operational status. It includes the technical and management functions required for planning, scheduling, performing and statusing of site conversion and/or new construction; the material and services to provide for the installation of Support Equipment, and all interconnecting cabling and fluid distribution systems at the site; and the performance of the complete system checkout or shakedown to insure readiness to accept the orbiter and booster for checkout and launch.

4.4.2 FERRY & ALTERNATE LANDING SITE

This element includes all of the facilities required at other than the main base for recovery of the Booster and/or Orbiter for ferry operations and when alternate landing conditions exist. These facilities include any accommodations necessary to accept these vehicles for landing and rollout, safing, servicing, payload removal and storage and preparation of the vehicles for ferry operations to the main base. It includes all design, development, construction and activation of these facilities.

Activation refers to the effort required to achieve operational status. It includes the technical and management functions required for planning, scheduling, performing and statusing of site conversion and/or new construction; the material and services to provide for the installation of Support Equipment, and all interconnecting cabling and fluid distribution systems at the site; and the performance of the complete system checkout or shakedown to insure readiness to accept the orbiter and booster for checkout and launch.

4.4.3 MISSION SUPPORT FACILITIES

The mission control center element includes all the facilities and equipment unique to control and/or monitor the development flight tests. These facilities may include modifications to existing space programs facilities such as Launch Control Center, Houston Mission Control Center, or the Manned Space Flight Network, adapted to the shuttle system, and/or new facilities to support the shuttle program. This element includes all design, development, construction and activation of these types of facilities.

Activation refers to the effort required to achieve operational status. It includes the technical and management functions required for planning, scheduling, performing and statusing of site conversion and/or new construction; the material and services to provide for the installation of Support Equipment, and all interconnecting cabling and fluid distribution systems at the site; and the performance of the complete system checkout or shakedown to insure readiness to accept the orbiter and booster for checkout and launch.

4.4.4 MAINTENANCE AND REFURBISHMENT FACILITY

This element refers to the operational facilities required to maintain and/or refurbish the flight vehicles. It may include modifications to existing facilities to allow use for such operations as servicing and maintenance of the Booster and Orbiter vehicle and ground systems. It does include engineering, planning, design and layout, negotiating subcontracts, monitoring procurement, construction, installation, activation, cost surveillance, records, and reporting. It does not include like facilities at any alternate launching site or at the mission control center.

Activation refers to the effort required to achieve operational status. It includes the technical and management functions required for planning, scheduling, performing and statusing of site conversion and/or new construction; the material and services to provide for the installation of Support Equipment, and all interconnecting cabling and fluid distribution systems at the site; and the performance of the complete system checkout or shakedown to insure readiness to accept the orbiter and booster for checkout and launch.

4.4.5 RECOVERY FACILITY

This element refers to the main base facility to which the flight vehicles return for normal operational mission modes. This element includes, for example: air strip, safing facility, any special cargo handling facility and passenger and crew facility. It also includes engineering, planning, design and layout, negotiating subcontracts, monitoring procurement, construction, activation, installations, cost surveillance, records, and reporting during the construction period.

Activation refers to the effort required to achieve operational status. It includes the technical and management functions required for planning, scheduling, performing and statusing of site conversion and/or new construction; the material and services to provide for the installation of Support Equipment, and all interconnecting cabling and fluid distribution systems at the site; and the performance of the complete system checkout or shakedown to insure readiness to accept the orbiter and booster for checkout and launch.

4.4.6 COMPUTER SYSTEMS

This element refers to the facilities required to accept and process data and information generated for the space shuttle system to support the development flight test program. These facilities may include modification to existing space programs facilities adapted for the requirements peculiar to the shuttle system and/or new facilities to support the shuttle system. This element includes all design, development, construction and activation of these types of facilities to be located at the launch site or mission support facilities.

Activation refers to the effort required to achieve operational status. It includes the technical and management functions required for planning, scheduling, performing and statusing of site conversion and/or new construction; the material and services to provide for the installation of Support Equipment, and all interconnecting cabling and fluid distribution systems at the site; and the performance of the complete system checkout or shakedown to insure readiness to accept the orbiter and booster for checkout and launch.

4.4.7 HORIZONTAL FLIGHT TEST FACILITY

This element includes all the facilities required at other than the main base for preferry flight and horizontal flight testing of the Orbiter and Booster vehicles. The facilities may include modifications to existing facilities and/or new facilities to support the shuttle program. This element includes all design, development, construction and activation of these facilities.

Activation refers to the effort required to achieve operational status. It includes the technical and management functions required for planning, scheduling, performing and statusing of site conversion and/or new construction; the material and services to provide for the installation of Support Equipment, and all interconnecting cabling and fluid distribution systems at the site; and the performance of the complete system checkout or shakedown to insure readiness to accept the orbiter and booster for checkout and launch.

4.5 FLIGHT TEST MANAGEMENT

This is the Flight Test Program Manager's element. It sums the Administrative Management functions required for direction and control of the Flight Test Program. In addition to the Program Manager and his staff, this element includes project and functional management.

5.0 OPERATIONS

The Shuttle operations element sums all the effort and materials necessary to operate the total Shuttle system and maintain it in an operable condition after development of the total system capability (IOC) has been achieved. (The total Shuttle system encompasses all Booster and Orbiter vehicles, Support Equipment, facilities, and operating data.) Specifically, this element includes maintenance and refurbishment of the Booster and Orbiter vehicles after each flight in preparation for the next mission, and maintenance and refurbishment of all SE and facilities necessary to launch, recover and maintain the vehicles. It also includes all launch operations and services from Booster and Orbiter mating through vehicle installation on the launch pad to lift-off. All flight operations and services from lift-off through the complete Orbiter mission to Booster and Orbital touchdown and roll-out are also part of this element. This element is limited to manpower, services, consumables and operational spares.

5.1 FERRY OPERATIONS

This element sums all of the effort and materials required to perform ferry operations of the Orbiter and/or Booster to the M&R facility. It includes servicing the vehicles, ferry preparations, and transportation of special equipment to all landing sites.

5.1.1 ORBITER FERRY OPERATIONS

This element includes all the effort and materials required to perform ferry operations of the orbiter from the manufacturing site and/or alternate landing sites to the M&R facility. It is limited to the manpower and materials required for the preparation of the vehicles for ferry, the ferry flight, in-transit support through landing, and delivery to the M&R facility. This element excludes the services and materials provided at the alternate site(s) by the M&R function (e.g., safing and detanking). Transportation of Support Equipment and personnel to alternate landing sites is included.

5.1.2 BOOSTER FERRY OPERATIONS

This element includes all of the effort and materials required to perform ferry operations of the booster from alternate landing sites to the M&R facility. It is limited to the manpower and materials required for preparation of the booster for ferry, the ferry flight, in-transit support through landing, and delivery to the M&R facility. This element excludes the services and materials provided at the alternate site by the M&R function (e.g., safing and detanking). Transportation of Support Equipment and personnel to alternate landing sites is included.

5.2 GROUND OPERATIONS AND SERVICES

This element refers to all of the effort and materials required for planning and scheduling, test procedure preparation, support equipment integration, payload installation and interface verification, pre-mate checkout of the orbiter and booster at the M&R facility, orbiter/booster erection and mating, mated transport to the pad, all pad prelaunch operations and systems checkout through countdown and launch. Excluded from this element are the payload materials (propellants, cargo, etc.) and the propellants and gases required to prepare for and launch the Shuttle vehicle.

5.3 FLIGHT OPERATIONS & SERVICES

This element includes all of the effort and materials required to conduct and support the mated vertical flight of the Shuttle vehicle, the booster flyback and the orbiter mission and flyback. These include mission planning, flight crews, operations of ground based command, control, tracking and communications facilities in support of the total mission; the services required for data acquisition, processing and analysis in direct support of the mission, such as monitoring of mission progress and status, resolution of mission anomalies and in-process mission replanning; planning and control of recovery crew requirements, e.g., payload disposition, recovery site location and recovery equipment requirements; and mission consumables (with the exception of spares and repair parts, propellants and gases).

5.4 MAINTENANCE AND REFURBISHMENT

The maintenance and refurbishment element sums the effort and materials necessary to maintain the booster and orbiter vehicles and support equipment and facilities in an operable condition.

5.4.1 ORBITER

This element includes all effort and materials necessary to maintain the orbiters in a flight ready condition. It includes planning and scheduling, Support Equipment integration, test procedure preparation, maintenance, refurbishment, post-flight safing and inspection, and consumables other than spares, repair parts, propellants and gases. This element includes all orbiter maintenance activities which occur from shutdown after landing to preparation for pre-mate checkout and storage.

5.4.2 BOOSTER

This element includes all effort and materials necessary to maintain the boosters in a flight ready condition. It includes planning and scheduling, Support Equipment integration, test procedure preparation, maintenance, refurbishment, post-flight safing and inspection, and consumables other than spares, repair parts, propellants and gases. This element includes all booster maintenance activities which occur from shutdown after landing to preparation for premate checkout and storage.

5.4.3 SUPPORT EQUIPMENT AND FACILITIES

This element includes all effort and materials necessary to maintain all Shuttle system support equipment and facilities in an operable condition at all times. It includes such items as planning and scheduling, test procedure preparation, maintenance, checkout consumables other than spares, repair parts, propellants and gases, post-launch inspection, pad refurbishment, launch pad preparation and checkout, scheduled maintenance and unscheduled maintenance.

5.5 SHUTTLE SYSTEM SUPPORT AND SERVICES

The Shuttle support element sums all of the logistics management and other support to the total Shuttle system not specifically provided in the booster, orbiter and flight test elements. Specifically, this element includes logistics management during the operational life of the Shuttle program, operational training, maintenance of operational technical data and manuals, mission simulation in support of the operational phase, and propellants and gases.

5.5.1 LOGISTICS MANAGEMENT

Logistics management encompasses all effort associated with the management of the total Shuttle system logistics operation after system development. It includes provisioning, the management of inventory and distribution of normal and expedite supply/resupply of support materials, and statusing each supply support center.

5.5.2 TRAINING SERVICES AND AIDS

The training element includes all training required for operational flight and ground crew training during the operational life of the Shuttle system. This element includes plans, lessons and instruction.

5.5.3 TECHNICAL DATA (MANUALS, ETC.)

The technical data element includes the modification and distribution of all technical data required to operate, maintain and service the Shuttle system after the system becomes operational. Included herein are operating and maintenance manuals/procedures covering flight and ground systems, launch and recovery facilities, and other direct Shuttle system support elements.

5.5.4 MISSION PLANNING AND SIMULATION

This element includes activities and material required to perform simulated missions, or partial missions, on a real-time basis in order to upgrade and maintain flight personnel proficiency and to develop mission operating techniques and procedures.

5.5.5 PROPELLANTS & GASES

This element includes all of the propellants and gases required to conduct all missions and maintenance during the operational life of the shuttle system. Specifically excluded are payload propellants and gases.

5.6 FACILITIES

This element sums all of the effort and materials required during the operational phase of the program to design, develop, construct and/or modify and reactivate all facilities supporting the shuttle operations.

5.6.1 MAIN BASE

This element includes all effort and materials required during the operational phase of the program to design, develop, construct and/or modify, reactivate, launch, maintenance and refurbishment, and recovery facilities.

5.6.2 FERRY & ALTERNATE LANDING SITE

This element includes all of the effort and materials required during the operational phase of the program to design, develop, construct and/or modify and reactivate facilities at selected ferry and alternate landing sites.

5.6.3 MISSION SUPPORT FACILITIES

This element includes all of the effort and materials required during the operational phase of the program to design, develop, construct and/or modify and reactivate the mission support facilities.

5.6.4 COMPUTER SYSTEMS

This element includes all of the effort and materials required during the operational phase of the program to design, develop, construct and/or modify and reactivate computer system facilities required to support the space shuttle.

5.7 OPERATIONS MANAGEMENT

This is the Operations Program Manager's element. It sums the Administrative Management functions required for direction and control of the Operations Program. In addition to the Program Manager and his staff, this element includes project and functional management.

6.0 SHUTTLE MANAGEMENT AND INTEGRATION

Shuttle Program Management and Integration includes program-level activities required to establish and control interface relationships among the principle elements of the Shuttle program, e.g., Orbiter, Booster, Main Engines, Flight Test and Operations, etc.; and also the interface relationships with other aerospace programs.

6.1 PROGRAM MANAGEMENT

This is the Space Shuttle Program Management element. It includes the administrative and management activities which are "level of effort" in nature. It includes the functions of configuration management, data management, Shuttle program planning and scheduling and management visibility reporting.

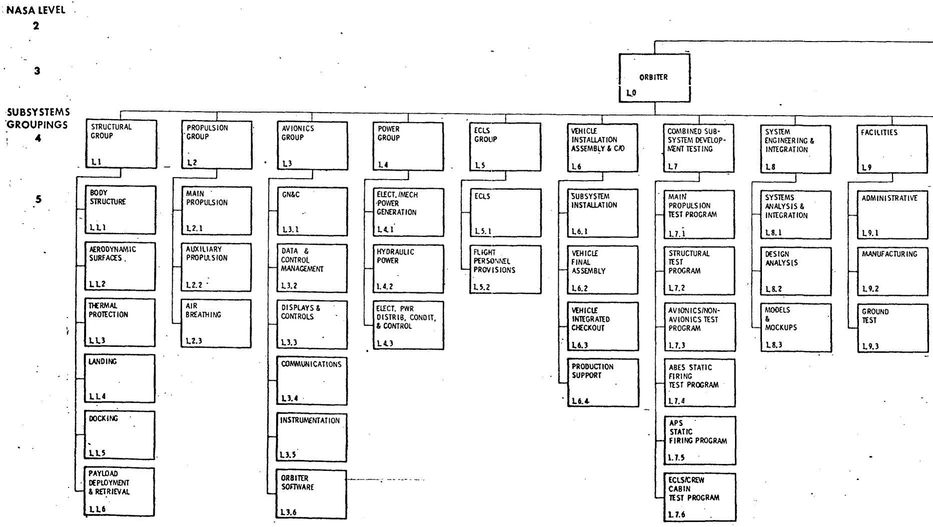
Specific products include Shuttle program master schedules, program reports, program management reviews, data publication and dissemination, change control documentation, and configuration control documentation.

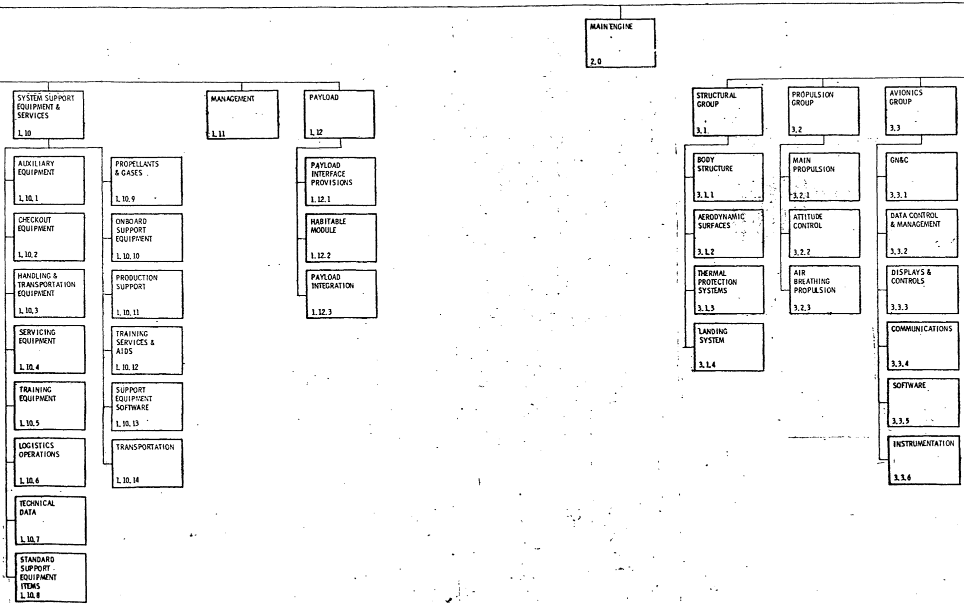
6.2 SYSTEM ENGINEERING AND INTEGRATION

This element provides for the effort required to establish requirements for the design, analysis and integration of the total system and designated common items. It also includes the analytical effort required to support the development of designs and that effort required to verify compatibility of designs with requirements and to control and direct the activities for integration of the system.

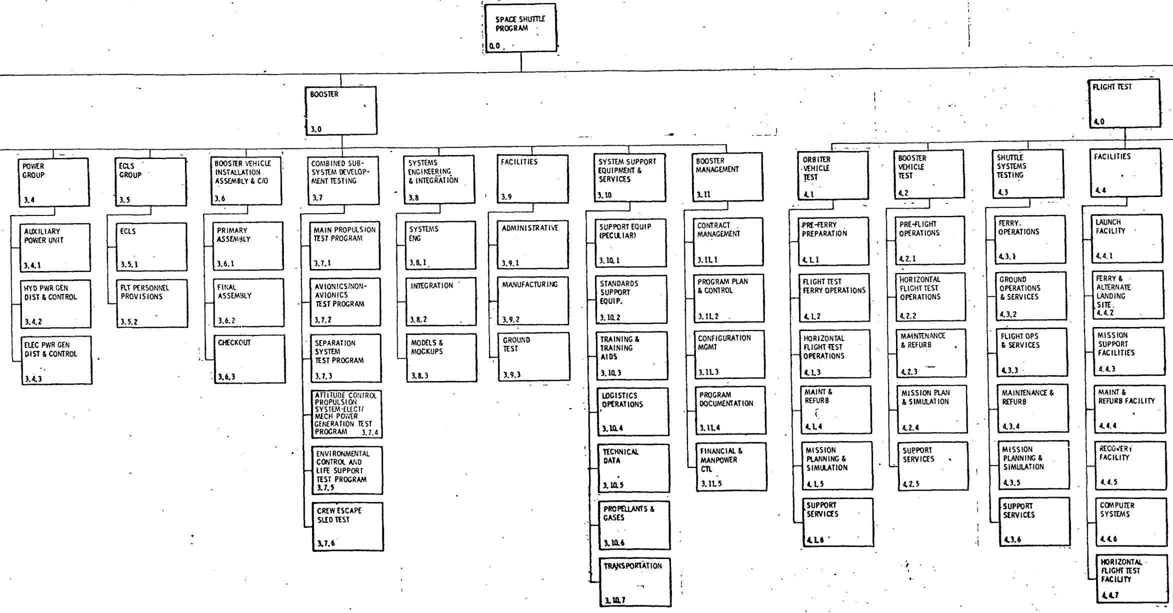
6.3 PAYLOAD INTEGRATION

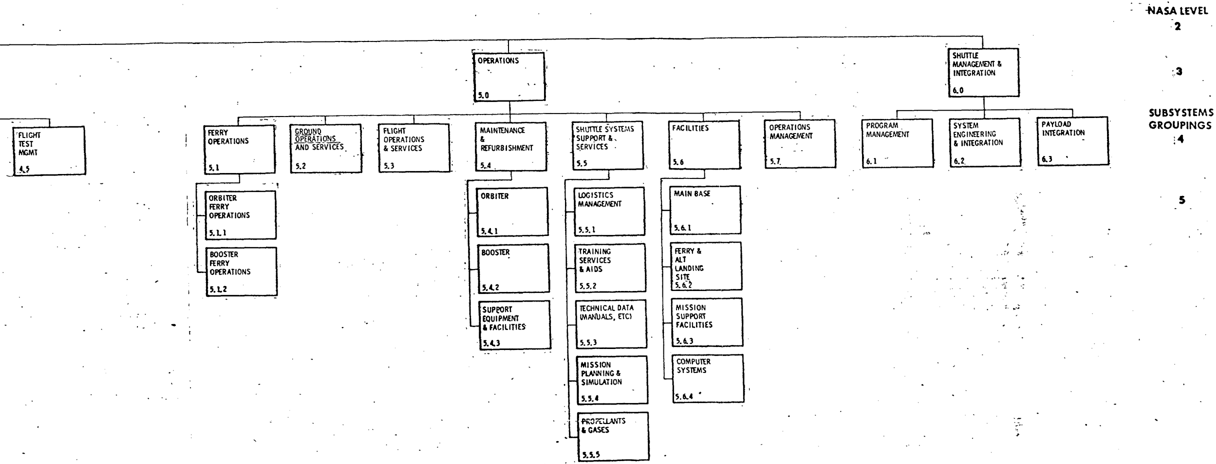
This element contains the activities required to plan the payload integration activities to support the various flights, assure the physical and functional integration and interface definition of payloads with the Space Shuttle system, develop the procedural interface activities for payloads with the system, provide mission planning and operations support, and the cataloging of discrete payloads.


NASA LEVEL
2
3
SUBSYSTEMS GROUPINGS
4
5
ORBITER
1.0
STRUCTURAL GROUP
1.1
BODY STRUCTURE
1.1.1
AERODYNAMIC SURFACES
1.1.2
THERMAL PROTECTION
1.1.3
LANDING
1.1.4
DOCKING
1.1.5
PAYLOAD DEPLOYMENT & RETRIEVAL
1.1.6
PROPULSION GROUP
1.2
MAIN PROPULSION
1.2.1
AUXILIARY PROPULSION
1.2.2
AIR BREATHING
1.2.3
AVIONICS GROUP
1.3
GN&C
1.3.1
DATA & CONTROL MANAGEMENT
1.3.2
DISPLAYS & CONTROLS
1.3.3
COMMUNICATIONS
1.3.4
INSTRUMENTATION
1.3.5
ORBITER SOFTWARE
1.3.6
POWER GROUP
1.4
ELECT./MECH POWER GENERATION
1.4.1
HYDRAULIC POWER
1.4.2
ELECT. PWR DISTRIB, CONDIT, & CONTROL
1.4.3
ECLS GROUP
1.5
ECLS
1.5.1
FLIGHT PERSONNEL PROVISIONS
1.5.2
VEHICLE INSTALLATION ASSEMBLY & C/O
1.6
SUBSYSTEM INSTALLATION
1.6.1
VEHICLE FINAL ASSEMBLY
1.6.2
VEHICLE INTEGRATED CHECKOUT
1.6.3
PRODUCTION SUPPORT
1.6.4
COMBINED SUBSYSTEM DEVELOPMENT TESTING
1.7
MAIN PROPULSION TEST PROGRAM
1.7.1
STRUCTURAL TEST PROGRAM
1.7.2
AVIONICS/NON-AVIONICS TEST PROGRAM
1.7.3
ABES STATIC FIRING TEST PROGRAM
1.7.4
APS STATIC FIRING PROGRAM
1.7.5
ECLS/CREW CABIN TEST PROGRAM
1.7.6
SYSTEM ENGINEERING & INTEGRATION
1.8
SYSTEMS ANALYSIS & INTEGRATION
1.8.1
DESIGN ANALYSIS
1.8.2
MODELS & MOCKUPS
1.8.3
FACILITIES
1.9
ADMINISTRATIVE
1.9.1
MANUFACTURING
1.9.2
GROUND TEST
1.9.3


MAIN ENGINE 2.0
SYSTEM SUPPORT EQUIPMENT & SERVICES 1.10
AUXILIARY EQUIPMENT 1.10.1
CHECKOUT EQUIPMENT 1.10.2
HANDLING & TRANSPORTATION EQUIPMENT 1.10.3
SERVICING EQUIPMENT 1.10.4
TRAINING EQUIPMENT 1.10.5
LOGISTICS OPERATIONS 1.10.6
TECHNICAL DATA 1.10.7
STANDARD SUPPORT EQUIPMENT ITEMS 1.10.8
PROPELLANTS & GASES 1.10.9
ONBOARD SUPPORT EQUIPMENT 1.10.10
PRODUCTION SUPPORT 1.10.11
TRAINING SERVICES & AIDS 1.10.12
SUPPORT EQUIPMENT SOFTWARE 1.10.13
TRANSPORTATION 1.10.14
MANAGEMENT 1.11
PAYLOAD 1.12
PAYLOAD INTERFACE PROVISIONS 1.12.1
HABITABLE MODULE 1.12.2
PAYLOAD INTEGRATION 1.12.3
STRUCTURAL GROUP 3.1
BODY STRUCTURE 3.1.1
AERODYNAMIC SURFACES 3.1.2
THERMAL PROTECTION SYSTEMS 3.1.3
LANDING SYSTEM 3.1.4
PROPULSION GROUP 3.2
MAIN PROPULSION 3.2.1
ATTITUDE CONTROL 3.2.2
AIR BREATHING PROPULSION 3.2.3
AVIONICS GROUP 3.3
GN&C 3.3.1
DATA CONTROL & MANAGEMENT 3.3.2
DISPLAYS & CONTROLS 3.3.3
COMMUNICATIONS 3.3.4
SOFTWARE 3.3.5
INSTRUMENTATION 3.3.6

PHASE B - CONTRACT NAS9 - 10960, DRL ITEM 19, DRD MF003M; PARA. 7
PHASE C/D WORK BREAKDOWN STRUCTURE


SPACE SHUTTLE PROGRAM 0.0
BOOSTER 3.0
POWER GROUP 3.4
AUXILIARY POWER UNIT 3.4.1
HYD PWR GEN DIST & CONTROL 3.4.2
ELEC PWR GEN DIST & CONTROL 3.4.3
ECLS GROUP 3.5
ECLS 3.5.1
FLT PERSONNEL PROVISIONS 3.5.2
BOOSTER VEHICLE INSTALLATION ASSEMBLY & C/O 3.6
PRIMARY ASSEMBLY 3.6.1
FINAL ASSEMBLY 3.6.2
CHECKOUT 3.6.3
COMBINED SUB-SYSTEM DEVELOPMENT TESTING 3.7
MAIN PROPULSION TEST PROGRAM 3.7.1
AVIONICS/NON-AVIONICS TEST PROGRAM 3.7.2
SEPARATION SYSTEM TEST PROGRAM 3.7.3
ATTITUDE CONTROL PROPULSION SYSTEM-ELECT/MECH POWER GENERATION TEST PROGRAM 3.7.4
ENVIRONMENTAL CONTROL AND LIFE SUPPORT TEST PROGRAM 3.7.5
CREW ESCAPE SLED TEST 3.7.6
SYSTEMS ENGINEERING & INTEGRATION 3.8
SYSTEMS ENG 3.8.1
INTEGRATION 3.8.2
MODELS & MOCKUPS 3.8.3
FACILITIES 3.9
ADMINISTRATIVE 3.9.1
MANUFACTURING 3.9.2
GROUND TEST 3.9.3
SYSTEM SUPPORT EQUIPMENT & SERVICES 3.10
SUPPORT EQUIP (PECULIAR) 3.10.1
STANDARDS SUPPORT EQUIP. 3.10.2
TRAINING & TRAINING AIDS 3.10.3
LOGISTICS OPERATIONS 3.10.4
TECHNICAL DATA 3.10.5
PROPELLANTS & GASES 3.10.6
TRANSPORTATION 3.10.7
BOOSTER MANAGEMENT 3.11
CONTRACT MANAGEMENT 3.11.1
PROGRAM PLAN & CONTROL 3.11.2
CONFIGURATION MGMT 3.11.3
PROGRAM DOCUMENTATION 3.11.4
FINANCIAL & MANPOWER CTL 3.11.5
FLIGHT TEST 4.0
ORBITER VEHICLE TEST 4.1
PRE-FERRY PREPARATION 4.1.1
FLIGHT TEST FERRY OPERATIONS 4.1.2
HORIZONTAL FLIGHT TEST OPERATIONS 4.1.3
MAINT & REFURB 4.1.4
MISSION PLANNING & SIMULATION 4.1.5
SUPPORT SERVICES 4.1.6
BOOSTER VEHICLE TEST 4.2
PRE-FLIGHT OPERATIONS 4.2.1
HORIZONTAL FLIGHT TEST OPERATIONS 4.2.2
MAINTENANCE & REFURB 4.2.3
MISSION PLAN & SIMULATION 4.2.4
SUPPORT SERVICES 4.2.5
SHUTTLE SYSTEMS TESTING 4.3
FERRY OPERATIONS 4.3.1
GROUND OPERATIONS & SERVICES 4.3.2
FLIGHT OPS & SERVICES 4.3.3
MAINTENANCE & REFURB 4.3.4
MISSION PLANNING & SIMULATION 4.3.5
SUPPORT SERVICES 4.3.6
FACILITIES 4.4
LAUNCH FACILITY 4.4.1
FERRY & ALTERNATE LANDING SITE 4.4.2
MISSION SUPPORT FACILITIES 4.4.3
MAINT & REFURB FACILITY 4.4.4
RECOVERY FACILITY 4.4.5
COMPUTER SYSTEMS 4.4.6
HORIZONTAL FLIGHT TEST FACILITY 4.4.7


NASA LEVEL
2
3
SUBSYSTEMS GROUPINGS
4
5
OPERATIONS 5.0
SHUTTLE MANAGEMENT & INTEGRATION 6.0
FLIGHT TEST MGMT 4.5
FERRY OPERATIONS 5.1
GROUND OPERATIONS AND SERVICES 5.2
FLIGHT OPERATIONS & SERVICES 5.3
MAINTENANCE & REFURBISHMENT 5.4
SHUTTLE SYSTEMS SUPPORT & SERVICES 5.5
FACILITIES 5.6
OPERATIONS MANAGEMENT 5.7
PROGRAM MANAGEMENT 6.1
SYSTEM ENGINEERING & INTEGRATION 6.2
PAYLOAD INTEGRATION 6.3
ORBITER FERRY OPERATIONS 5.1.1
BOOSTER FERRY OPERATIONS 5.1.2
ORBITER 5.4.1
BOOSTER 5.4.2
SUPPORT EQUIPMENT & FACILITIES 5.4.3
LOGISTICS MANAGEMENT 5.5.1
TRAINING SERVICES & AIDS 5.5.2
TECHNICAL DATA (MANUALS, ETC) 5.5.3
MISSION PLANNING & SIMULATION 5.5.4
PROPELLANTS & GASES 5.5.5
MAIN BASE 5.6.1
FERRY & ALT LANDING SITE 5.6.2
MISSION SUPPORT FACILITIES 5.6.3
COMPUTER SYSTEMS 5.6.4